A COMMISSION STUDY

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733 W. FOURTH AVE.
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FEDERAL-STATE LAND USE PLANNING COMMISSION FOR ALASKA

NORTHERN ALASKA HYDROCARBON RESOURCES

BY

JERRY D. KREITNER

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The Commission finds that the report is well documented and researched and that the conclusions are soundly based; however, the recommendations contained in this report are those of the authors and not necessarily the recommendations of the Commission.

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SUMMARY

The discovery of oil and gas at Prudhoe Bay in 1968, the Native Claims Settlement Act of 1971, and the 1976 winter energy shortages throughout the Midwestern and Eastern United States has resulted in a significant increase in oil and gas exploration activity in northern Alaska. This increased activity includes a 182-million-dollar Federal program for evaluating the oil and gas potential of the National Petroleum Reserve-Alaska (NPRA); a proposed joint Federal-State Beaufort Sea Outer Continental Shelf lease sale in 1979; exploration and drilling activities on Native corporation lands in the Western Arctic Area and Brooks Range Foothills; and increased industry activity along the coastal area from the vicinity of the Kuparuk River on the west to Flaxman Island on the east, where Exxon recently announced what may be a significant oil and gas discovery.

To facilitate the congressionally mandated study of NPRA, the U.S. Geological Survey subdivided northern Alaska into the following four structural belts or trends:

1. Brooks Range
2. Southern Foothills
3. Colville Trough
4. Barrow Arch

In a similar hydrocarbon development study, the State of Alaska Department of Natural Resources subdivided northern Alaska into five "activity areas":

1. Western Arctic Area (WAA)
2. National Petroleum Reserve-Alaska (NPRA)
3. Prudhoe Bay State Area (PBSA)
4. Central North Slope Area (CNSA)
5. Arctic National Wildlife Range (ANWR)

In general, both studies concluded that the Barrow Arch, which trends adjacent to and parallel with the Arctic coastline, has the highest potential for containing additional economic accumulations of oil and gas. Both reports, as well as a separate study prepared by the Bureau of Land Management Outer Continental Shelf Office, further identified the following specific areas which are thought to have potential for containing additional economic oil and gas fields:

1. Nearshore Beaufort Sea
2. Flaxman Island-Point Thompson area
3. Kuparuk River Formation west of Prudhoe Bay (onshore)
4. Extreme northeast part of NPRA (onshore)
5. Jago River-Marsh Creek area in ANWR

From the Barrow Arch, the sedimentary sequence dips to the south where it reaches its maximum thickness of more than 30,000 feet in the deepest part of the west-plunging Colville Trough. Throughout this area, as well as in the foothills of the Brooks Range, the controlling stratigraphic and structural relationships responsible for the Prudhoe Bay field probably do not exist; and it is anticipated that if oil and gas fields are present, they will occur in relatively small, isolated, structural, stratigraphic, and combination traps of Cretaceous age similar to the presently sub-economic oil and gas fields at Umiat and Gubik.

It is important to note that, although the Barrow Arch appears to possess the highest oil and gas potential, especially offshore, other areas further to the south do have some potential. However, because of present day economics which indicate minimum economic field size may range from 280 to 930 million barrels of oil equivalent, lack of information, drilling depth limitations, and a multitude of assumed environmental disruptions, the hydrocarbon potential of most of the area south of the Barrow Arch may remain unknown for years, if not forever.

Similar complications are expected in the Southern Foothills area where natural gas is anticipated in complex structural traps. Increasing exploration costs with depth, access problems, and conflicts with other resources may severely restrict, if not preclude, development of any hydrocarbon resources in this area as well as in much of the Colville Trough and remainder of the Brooks Range Foothills.

Preliminary exploration results in NPRA indicate slight likelihood of finding additional Prudhoe Bay type accumulations, except possibly in the extreme northeastern part of the reserve. However, the oil and gas potential even within this assumed prime northeastern portion of NPRA appears less encouraging in view of the recent Drew Point test well results. This well reportedly did not discover commercial shows and was plugged and abandoned in early March, 1978 (Ref. 16).

In an analysis of all available data, the Federal Energy Administration (FEA) identified 46 structures within NPRA with between 100 and 500 million barrels of oil capacity. Unfortunately, since the minimum economic field size has been estimated to vary between 280 and 930 million barrels of oil, many of these relatively small, isolated oil and gas fields will most likely not be economic. The FEA further concluded that private development of NPRA is favored; however, some relaxing of existing pipeline tariffs and leasing procedures would be necessary for private developers to realize a profit.

The hydrocarbon potential of the Western Arctic Area (WAA), just west of NPRA is essentially unknown at this time. However, the State of Alaska Department of Natural Resources feels that this subregion does not possess high hydrocarbon potential. Their evaluation is based upon very limited data and may be substantially changed with the results of two super tight exploratory wells which are currently being drilled on

Arctic Slope Native corporation lands by Chevron. One well, the Eagle Creek No. 1, is located in the Southern Foothills of the WAA and the other is in the Central North Slope Area (CNSA) further to the east on the Tiglukpuk structure by Anaktuvuk Pass.

Oil and gas economics for the WAA, as well as for most of NPRA, will be directly influenced by distance to the present pipeline corridor and possible restrictions associated with crossing as many as five proposed wild and scenic rivers. As a result, any resulting production may have to depend upon alternative transportation modes, such as ice-breaking tankers from areas such as Point Hope or the Seward Peninsula, if they are to be economic.

Within the Prudhoe Bay State Area (PBSA), future oil and gas exploration is anticipated along the entire coastline from the Colville River to the ANWR. Further to the south in the CNSA, existence of decollement structures and other unsatisfactory stratigraphic and structural relationships essentially eliminates any possibility of finding additional Prudhoe Bay type fields. However, this is not meant to imply there is no potential within this area. Existence of relatively small oil fields such as Umiat and gas fields such as Gubik, Kemik, and Kavik warrants further exploration.

The onshore area, which is thought to have the highest potential for additional large accumulations of oil and gas, is within the Coastal Plain of the Arctic National Wildlife Range (ANWR). The presence of extremely rich source beds, beds with excellent reservoir characteristics, oil seeps, outcrops of oil saturated sandstones, and two large structures at Marsh Creek and between the Jago and Okpilak Rivers just southeast of Barter Island, suggests that this area may contain oil and gas reserves equivalent to, or possibly greater than, the Prudhoe Bay field.

The recent significant oil and gas discoveries announced by Dome Oil Company in the Canadian Beaufort Sea and by Exxon at Flaxman Island some 55 miles east of Prudhoe Bay, strongly suggest that the Alaskan Beaufort Sea has the highest potential for large accumulations of oil and gas of any area within Alaska. This is further strengthened by the existence of oil seeps and Tertiary oil sand outcrops in the ANWR Coastal Plain, the possibility of finding additional Cretaceous oil similar to the Flaxman Island well, and the possibility of finding oil and gas in some of the older Paleozoic and Mesozoic rocks along the Barrow Arch.

A large portion of the presently available Federal and State onshore land with relatively high oil and gas potential has already been leased between the ANWR and NPRA. Within this area, recent discoveries have been announced by Exxon near Flaxman Island and Point Thompson. These discoveries in conjunction with Kuparuk River development west of Prudhoe Bay and possible development of NPRA, especially in the extreme northeast portion along the coast, could, in all likelihood, result in elevated gathering and transmission lines with associated roadway networks along the entire coastline from Barrow to the Wildlife Range. These impacts

will further be compounded by required onshore facilities for processing and transporting anticipated Beaufort Sea oil and gas reserves.

Recent proposals by Dome Petroleum of Canada, and reports by Global Marine, Inc., U.S. Maritime Administration (MARAD) and others, indicate that oil and gas can be shipped from northern Alaska to either east or west coast markets via ice-breaking tanker systems more economically than with existing or proposed pipelines. For example, Dome Oil reported they can deliver Prudhoe Bay oil to Philadelphia for $5.06 per barrel and natural gas, including regasification cost, to eastern markets for $3.40/MCF. To accomplish this, Dome plans to order a class 10 icebreaker with 150,000+SHP to support year-round exploration and delivery of Canadian Arctic Island and Mackenzie Delta oil and gas.

In a presentation to the Federal Energy Office, USGS, and FEA during January, 1978, Dome suggested that the U.S. contribute $15 million per year for three years after 1980 to support the feasibility tests and Arctic ice research programs. In return, the United States would have access to all research data, including sea ice characteristics, weather, currents, and ship response and reliability in various ice and weather conditions.

If Dome's proposal is successful, it may enable year-round shipping, drilling, and seismic operations in portions of the Beaufort Sea. This would result in reduced operating costs and would offer an effective means of implementing a workable oil spill cleanup program in adverse ice and weather conditions. Such a program is important in view of the proposed Beaufort Sea tanker traffic and the Canadian drilling activity 30 miles east of the ANWR.

Recently proposed Federal, State, and local policies for accelerated exploration and development of northern Alaska oil and gas resources may be detrimental to many of the socioeconomic, environmental, and technical concerns in the Arctic. Such policies include the congressionally mandated accelerated pace for exploring and evaluating the potential of the NPRA by 1980; a recent proposal to conduct a similar five-year hasty evaluation of the ANWR; a joint Federal-State agreement for a Beaufort Sea lease sale in 1979; and the urgency which has been imposed upon the Native corporation for evaluating their land selections.

The need to evaluate and eventually develop these resources is important to the State of Alaska and the nation as a whole; however, equally important is the time frame in which this program is implemented. Therefore, a joint Federal, State and private resource leasing, development, and transportation plan is recommended to insure that future Alaskan development proceeds in a manner which minimizes all possible adverse impacts. The resulting plan could ultimately be incorporated into an international operating agreement with Canada to insure that development of Arctic resources is accomplished in a manner which minimizes negative impacts, maximizes economic return, and insures sufficient uniform protection for the entire Arctic area.

EXPLORATION AND DEVELOPMENT CRITERIA

Introduction

The following compilation of industry criteria, construction cost data, and general information pertaining to petroleum exploration and development was prepared in support of a northern Alaska policy study prepared by J. D. Dorris of the Federal-State Land Use Planning Commission. This document, which consists of information obtained from various Federal and State agencies, oil and gas industry personnel, and several oil and gas publications, briefly describes the geology, anticipated resources, and some of the technical, economic, and environmental factors which must be considered in establishing any land use policies.

Development of realistic industry criteria which accurately reflects minimum economic field size for oil or gas production is extremely difficult to achieve with available present-day information. This is particularly true in remote northern Alaska where each field must be evaluated on a site specific basis under a unique and complex array of political, environmental, technical, and economic considerations.

The United States Geological Survey (USGS) (Ref. 2, 4, and 10) has subdivided northern Alaska into four main structural belts or trends (Figs. 1, 2, and 3).

1. Brooks Range geanticline (mainly Paleozoic)
2. Southern Foothills disturbed belt of shallow thrusts (Mesozoic)
3. Colville Trough (mainly Cretaceous), which is further subdivided into the Northern Foothills and Coastal Plain Provinces
4. Barrow Arch

The State of Alaska (Ref. 7) divided the northern Alaska petroleum province into five distinct "activity areas" (Fig. 4). The five "activity areas," whose boundaries coincide for the most part with political boundaries, are:

1. National Petroleum Reserve Alaska (NPRA)
2. Western Arctic Area (WAA)
3. Prudhoe Bay State Area (PBSA)
4. Central North Slope Area (CNSA)
5. Arctic National Wildlife Range (ANWR)

A sixth area, which may possess the greatest potential for additional Prudhoe Bay type hydrocarbon accumulations, is the Beaufort and Chukchi Sea Outer Continental Shelf.

The following general and specific comments relating to industry criteria for hydrocarbon development are referenced to the State's "activity areas" (Fig. 4), or the four USGS units delineated in Figures 1, 2, and 3.

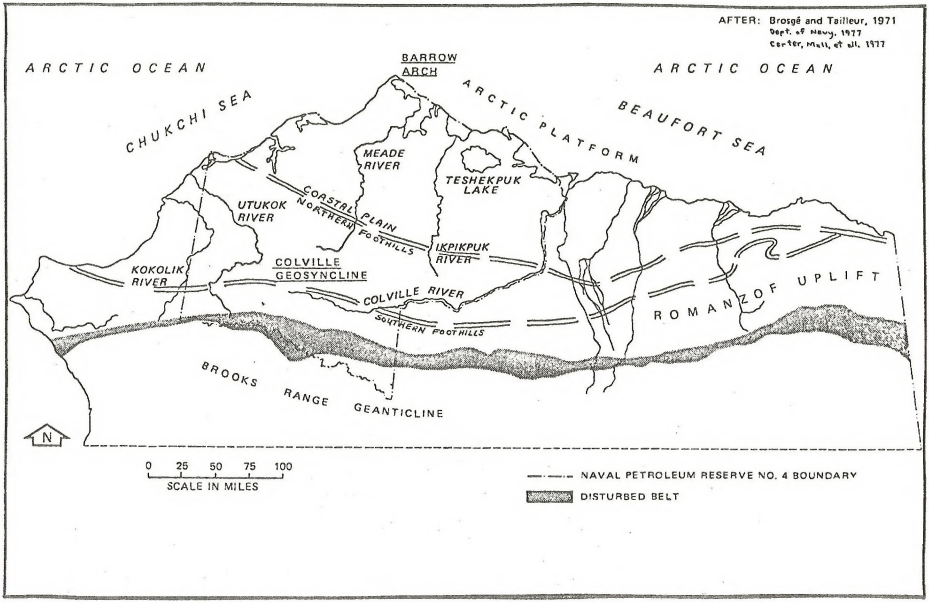
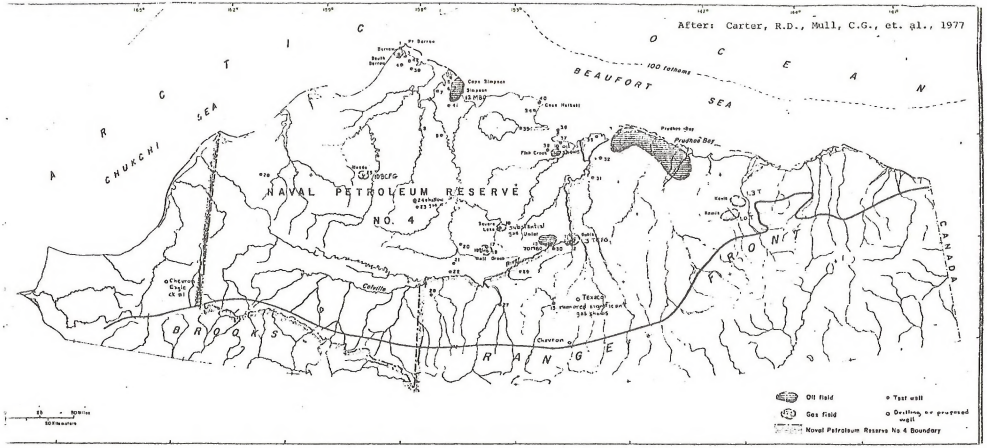


FIGURE 1: PHYSIOGRAPHIC DIVISION, EXPLORATION TRENDS, AND STRUCTURAL BELTS OF NORTHERN ALASKA



TEST WELLS

1. South Barrow	1	8. Topagoruk	1	14. Umiat	2-11	21. Knifeblade	1	28. Texaco W. Kurupa	1	33. Gulf Colville Delta	1	40. W. T. Foran	1
2. South Barrow Gas Field		9. East Topagoruk	1	15. Umiat	1	22. Knifeblade	2-2A	29. Arco Schrader	1	34. Cape Halkett	1	41. South Simpson	1
3. Avak	1	10. Fish Creek	1	16. Square Lake	1	23. East Dumalik	1	30. McCulloch Colville	1,2	35. East Teshekpuk	1	42. South Barrow	12,14
4. South Barrow	3	11. Gubik	1	17. Wolf Creek	2	24. Dumalik	1	McCulloch E. Umiat	2	36. Iko	1		
5. North Simpson	1	Colorado Oil & Gas	1	18. Wolf Creek	1	25. Meade	1	Brit. Pet. E. Umiat		37. South Harrison Bay	1		
6. Minga (velocity test)	1	12. Gubik	2	19. Wolf Creek	3	26. Kaolak	1	31. Area Itkilliik	1	38. Atigaru Point	1		
7. Simpson	1	13. Grandstand	1	20. Titaluk	1	27. Texaco E. Kurupa	1	32. Union Kookpuk	1	39. West Fish Creek	1		

FIGURE 2 - INDEX MAP: NPRA TEST WELLS, OIL AND GAS FIELDS, NORTH SLOPE OF ALASKA

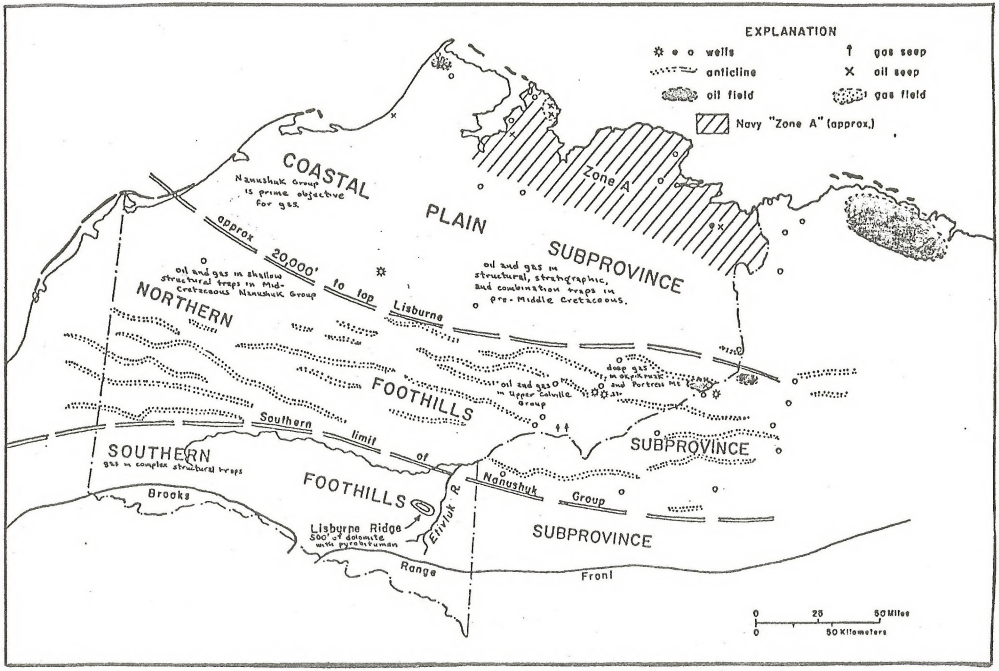


FIGURE 3: EXPLORATION TRENDS, NPRA

After: Alaska Department of
Natural Resources,
August, 1977

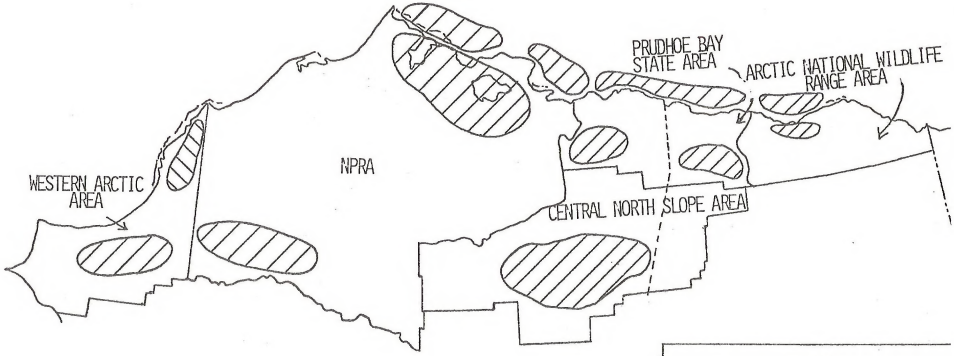


FIGURE 4: Potential Petroleum Development Areas

National Petroleum Reserve Alaska

National Petroleum Reserve Alaska (NPRA), formerly NPR-4, is located on the North Slope of Alaska about 75 miles west of Prudhoe Bay (Figs. 1-4).

Results of the exploratory wells drilled by the Navy after World War II, and the current USGS exploration program, indicate that three broad exploration trends (Fig. 3) with a number of plays can be expected in NPRA (Ref. 4, page 5). These trends are:

1. Coastal Plain trend, which is prospective for oil and gas in structural, stratigraphic, and combination traps in pre-Middle Cretaceous rocks;
2. the Northern Foothills trend, with possible oil and gas in shallow, structural traps of Cretaceous age; and
3. the Southern Foothills trend, where gas may be found in complex structural traps in Mississippian, Triassic, and Lower Cretaceous rocks.

Carter and Mull (Ref. 4) state, "current knowledge on North Slope geology suggests several hydrocarbon plays that might be considered in assessing the potential of the Reserve. Analysis of the plays indicates slight likelihood of Prudhoe Bay type accumulations." They also state, "Two of the most important Prudhoe Bay reservoirs, the Lisburne and Sadlerochit, may be present in a favorable structural-stratigraphic position only in the extreme northeastern part of NPR-4."

Estimates of reserves have ranged from zero to as high as 100 BBO and 148 TCFG (Table 1). G. Mull of the USGS was quoted in the Anchorage Daily News (Thursday, April 7, 1977) as stating, "the NPRA may contain as little as 1 to 3 billion barrels of oil." Known oil and gas fields in NPRA are shown in Figures 2 and 3, and reserve estimates and producing horizons are included in Table 2.

In view of all available geological and geophysical information, the eastern section of NPRA and limited areas along the northern coastline appear to possess the greatest hydrocarbon potential. Although other portions of NPRA are prospective for oil and gas, the anticipated relatively small size of the isolated fields may prohibit development because of marginal economics. Furthermore, several legal boundary disputes and possible impacts of (d)(2) lands legislation may hinder, if not totally prevent, development of many of these small isolated oil and gas fields in NPRA, and on Native lands to the west.

For example, the Federal Energy Administration (FEA) (Ref. 6, page 9) states:

TABLE I

Estimates of Recoverable Resources for NPRA

Date	Recoverable Reserve Estimates		Source
	Billions Barrels Oil	Trillions Cubic Feet Gas	
Nov. 25, 1968	(Hendricks) 2.68-32.38 (Weeks) 11.84-33.15	9.25-148.00 ---	U.S. Geological Survey, Conservation Division preliminary report based upon T. A. Hendricks' and L. G. Weeks' methods of resource estimation.
Feb. 5, 1969	9.66	1.06	U.S. Geological Survey, Conservation Division, A. A. Wanek unpublished report.
Apr. 28, 1969	9.70	1.06-31.90	Memorandum to Director, Bureau of Land Management from Director, U.S. Geological Survey, by A. A. Baker.
Apr. 21, 1970	14.30	78.65	The Arctic Institute of North America, John C. Reed, Institute Senior Scientist. A revision, based on additional information, of an earlier report giving reserves of 4.49 billion barrels of oil and 25.28 trillion cubic feet of gas.
December, 1974	10.00-33.00	80.00	Bob Porterfield, reporter, Alaska Construction and Oil, p. 10.
Dec. 13, 1974	33.00	---	Richard Corrigan, reporter, Anchorage Daily News.
Dec. 21, 1974	"Bust"-400.00	---	Richard Murphy, Navy Petroleum Engineer, quoted in Anchorage Daily News article by Bruce Ingersoll.
Dec. 23, 1974	33.00	80.00	Bruce Ingersoll, reporter, Anchorage Daily News.
Jan. 14, 1975	33.00	---	Bruce Ingersoll, reporter, Anchorage Daily News.
Jan. 19, 1975	33.00	---	The Denver Post, p. 9.
April, 1975	35.00	---	Alaska Construction and Oil.

TABLE I (Continued)

Date	Recoverable Reserve Estimates		Source
	Billions Barrels Oil	Trillions Cubic Feet Gas	
May, 1975	* 5.00-16.00 (Statistical mean=10)	* 14.00-49.00 (Statistical mean=28)	* Estimates for entire North Slope. U.S. Geological Survey Circular 725, p. 33.
June 2, 1975	10.00-33.00	80.00	The Oil and Gas Journal, p. 104.
Nov. 11, 1975	10.00-33.00	80.00	Gerson Yalowitz, reporter, U.S. News and World Report.
Nov. 24, 1975	100.00	---	Terence J. Woods, Officer-in-Charge, NPR-4, quoted in Anchorage Daily News.
February, 1976	33-100 "Another Kuwait"-Senator Henry Jackson		Bob Yaskell, reporter, Alaska Construction and Oil.
Mar. 3, 1976	"....equivalent...Prudhoe Bay." (9.6 billion)		Richard A. Fineberg, reporter, Anchorage Daily News, p. 12.
Mar. 15, 1976	33.00	---	The Oil and Gas Journal, p. 70.
Mar. 16, 1976	10.00-33.00 (USGS) "...as much as 50.00...". (BLM) "even 10.00... is speculative." (Lt. Cdr. Terry Woods)	---	Sally W. Jones, reporter, Anchorage Daily News.
April, 1976	* 1.00-3.00	* 3.20-10.60	* U.S. Geological Survey Administration Report. Based upon estimates by panel of Branch of Alaskan Geology and Branch of Oil and Gas Resources geologists.
Apr. 8, 1976	100.00	---	Anchorage Daily News, p. 6.
June, 1976	"...multi-billion barrel strike...".		Ralph Stefano quoted in Alaska Construction and Oil.

TABLE I (Continued)

Date	Recoverable Reserve Estimates		Source
	Billions Barrels Oil	Trillions Cubic Feet Gas	
August, 1976	5.00 (includes condensate)	14.30	Federal Energy Administration, Strategic Petroleum Reserve Office, Office of Oil and Gas. (Includes an erroneous informal USGS estimate of 2-8 billion barrels of oil and 7-25 trillion cubic feet of gas.
Aug. 9, 1976	5.00	14.30	The Oil and Gas Journal, p. 53.
October, 1976	5.00	14.30	Anne Ehrenburg, reporter, Alaska Construction and Oil, p. 48.
Mar. 16, 1977	15.00	80.00	Jack Anderson, reporter, San Francisco Chronicle.

TABLE II

Oil and Gas Fields, Alaska North Slope

Field	Production	Producing Formation		Reservoir Lithology	Approximate Depth of Production in feet	Identified Resource (Econ. & Subecon.) Million bbls. oil Billion c.f. gas
Umiat NPR-4	Oil	Lower Cret.	Nanushuk Group	Sandstone	250-1,350	70
Gubik	Gas	Upper Cret. Upper Cret.	Prince Creek Fm. Chandler-Ninuluk Fm. undiff.	Sandstone Sandstone	1,450-1,750 3,550	22-295
South Barrow NPR-4	Gas	Jurassic	?	Sandstone	2,500	18
Meade NPR-4	Gas	Lower Cret.	Nanushuk Group	Sandstone	4.200	10
Square Lake NPR-4	Gas	Upper Cret.	Seabee Fm.	Sandstone	1,650-1,850	33-58
Wolf Creek NPR-4	Gas	Lower Cret.	Nanushuk Group	Sandstone	1,500	No est.
Simpson NPR-4	Oil	Upper Cret.	Nanushuk-Seabee Fms.	Sandstone	300	
Fish Creek NPR-4	Oil	Lower Cret.	Topagoruk Fm.	Sandstone	3,000	
Prudhoe Bay	Oil	Jurassic	Kuparuk River	Sandstone	8,000	No est.
	Oil & Gas	Jurassic	Sag River Fm.	Sandstone	10,000	No est.
	Oil & Gas	U. Triassic	Shublik Fm.	Sandstone/Limestone	10,000	No est.
	Oil & Gas	L. Triassic-Perm.	Sadlerochit Grp.	Sandstone	10,500	*9.6 bill. bbls. 26.5 trillion cf
	Oil & Gas	Miss. & Penn.	Lisburne Grp.	Carbonates	11,500	No est.
Kavik	Gas	Triassic	Sag River Fm.	Sandstone	4,250	No est.
	Gas	Triassic	Sadlerochit Grp.	Sandstone	4,600	No est.
Kemik	Gas	Triassic	Shublik Fm.	Limestone	8,700	No est.

Sources: Harrison and others (1973); American Petroleum Institute and others (1974); Morgridge and Smith (1972)
*Measured Reserve

"Two separate boundary disputes now being contested in NPR-4 could slow the pace of Reserve development. First, the dispute over whether the Colville River bed is within or outside the Reserve could delay using its critical gravel resources to construct access roads, camps, and other development-related facilities. Second, the dispute over whether the Arctic coast boundary of the Reserve is the highest high-water mark or mean high-water mark and the inclusion or exclusion of certain bays in the reserve could delay exploratory drilling in Harrison Bay and other promising bays along the coast."

Another problem is the possible adverse impact which the proposed (d)(2) Wild and Scenic River legislation could have upon river crossings and gravel sources for access roads, airstrips, and drilling pads.

According to Mr. Lee D. Morrison (Ref. 9), the Wild and Scenic Rivers Act (WSRA) enables the Secretaries of Interior and Agriculture to grant easements and rights-of-way over "any component of the wild and scenic rivers system in accordance with the laws applicable...to the national park and national forest systems respectively, but any conditions precedent to granting of rights-of-way must be related to the policy and purpose of the WSRA." He further states, "This may seem to be of academic importance until one considers the effect on the MLA. Oil and gas pipeline rights-of-way are not authorized in national park system lands.[189] Therefore, any river designated under the WSRA which is administered by the Interior, could not be crossed by oil and gas pipelines, even if the river is merely designated as 'recreational'."

Access laws vary with the management system traversed and the transportation system involved. Therefore, in view of various interpretations of the intent of the existing WSRA, it will be necessary for Congress to institute remedial legislation to eliminate the anticipated problems associated with gravel extraction and access for oil and gas pipelines, as well as pipelines for other commodities, across components of the Wild and Scenic Rivers System.

The five river systems which are presently under consideration for inclusion into the Wild and Scenic Rivers System within NPRA are, from west to east:

1. Utukok River
2. Kuk-Ketik River
3. Colville River
4. Ikpikpuk River
5. Anaktuvuk River

The disposition of these proposed wild and scenic rivers is to be addressed by Congress during their deliberations on NPRA.

In the FEIS for NPRA (Ref. 5, page 528), it is stated, "Gravel is scarce on NPR-4, found only in some coastal areas of the Arctic Coastal

Plain and in some places along the Colville and Utukok rivers." If gravel extraction is not permitted from these two rivers, development may have to rely on use of fine grained sand, mined from upland areas where visual evidence of the mining operation will be present for several decades.

The Joint Federal-State Fish and Wildlife Advisory Team has often expressed (personal communication) their opposition to further stream gravel removal on the North Slope. Such action could severely hinder, if not completely halt, further development in northern Alaska. The environmental trade off, if any at all, will have to be carefully weighed if development is to continue.

Western Arctic Area

Lack of available information in the Western Arctic Area (WAA) makes resource evaluation difficult to achieve with any certainty. However, detailed geological information obtained in NPRA, regional data, and geological trends throughout northern Alaska can be extrapolated, with some certainty, into the area.

The State of Alaska (Ref. 7) outlined two areas of interest in WAA, as well as all other areas of northern Alaska, based on geological information and concentration of industry geological and geophysical activity (Fig. 4). Their evaluation revealed two areas within WAA which possess the greatest amount of hydrocarbon potential:

1. A thin belt of north-south trending Mississippian to Triassic sediments which is exposed on the Cape Lisburne Peninsula. The Lisburne formation exposed at this locality contains beds similar to the oil bearing limestones present at Prudhoe Bay. However, subsurface extent and depth of the formation throughout the WAA is unknown and its hydrocarbon potential is unassessed.

2. The other formations with some hydrocarbon potential are the Cretaceous age, Kukpowruk, and Corwin formations. The Kukpowruk has the highest potential of the two, but reservoir characteristics of samples collected indicate a decrease in reservoir potential from east to west. Therefore, it appears that the area with the greatest potential for Cretaceous production is the eastern part of the WAA.

The overlying Corwin formation is somewhat less promising than the Kukpowruk formation, but does contain a few beds with fair reservoir qualities. Corwin formation asphalt sands have been reported on the Kokalik River, and there are reports of an oil seep by Cape Beaufort.

In general, the State does not consider the WAA to have high hydrocarbon potential because the potential trapping mechanisms occur generally where the sediments have poor reservoir characteristics.

According to Petroleum Information Alaska Report (Ref. 15), Chevron U.S.A. plans to drill two exploratory wells on Arctic Slope Regional Corporation lands during the 1977-78 winter season. The first well, Tiglukpuk #1, will be drilled about 18 miles northeast of Anaktuvuk Pass, in the extreme southern portion of the Central North Slope Area. The second well (Eagle Creek #1) will be drilled in WAA about 90 miles east of Cape Lisburne and 15 miles west of NPRA. Chevron is expected to drill a second test in WAA the following year.

Field size, gravel and water availability, and right-of-way access for pipelines across NPRA and the five proposed wild and scenic rivers are especially critical to the development of this area. For example, pipeline access is so critical in this area that some industry personnel are seriously considering constructing a pipeline to the south from any resulting production to a tanker port at Nome. From there, oil would be trans-shipped via shallow-water, ice-breaking vessels to a port somewhere on the north side of the Alaska Peninsula. A short pipeline would then be used to transport the hydrocarbons to a deep-water, ice-free port on the south side of the Peninsula. This transportation network would involve constructing a pipeline through the following proposed National Park and Wildlife Systems:

1. Cape Krusenstern National Monument
2. possible portions of the Noatak National Preserve
3. Chukchi-Imuruk National Monument
4. Alaska Peninsula National Wildlife Refuge

Such activities, including the transport of hydrocarbons via tanker in the Bering Sea, will most likely result in strong opposition from environmental groups. Therefore, if commercial accumulations of hydrocarbons are discovered in WAA, it will be necessary to thoroughly evaluate the comparative environmental impacts and economics associated with this western tanker-pipeline route and a pipeline route across NPRA and the five, previously addressed, proposed wild and/or scenic rivers.

Exploration and development of the Native lands in this area, more so than in other areas of the North Slope, is dependent upon size and nature of the hydrocarbon deposit, exploration success and development policies in NPRA, and potential conflicts of (d)(2) land legislation with development and transportation facilities.

Prudhoe Bay State Area

The Prudhoe Bay State Area (PBSA) extends from the Beaufort Sea to the southern limit of State patented land, and contains the large Prudhoe Bay oil and gas field and the relatively small Kavik gas field near the Canning River (Fig. 4).

The Prudhoe Bay oil and gas field is located in the northern portion of this area on the northern flank of the Colville Trough and on the southeast plunging Barrow Arch (Figs. 2 and 3). The Prudhoe Bay field

and nearby wells contain and/or produce oil from the Lisburne Carbonate Group, the Sadlerochit Group, the Shublik Formation, and the Sag River and Kuparuk River sandstones.

The Kavik gas field (Fig. 2) contains about 1.3 TCFG in the Sag River sandstones and Sadlerochit Group (State Division of Oil and Gas, personal communication); whereas most gas observed in NPRA to date has been in Cretaceous age rocks.

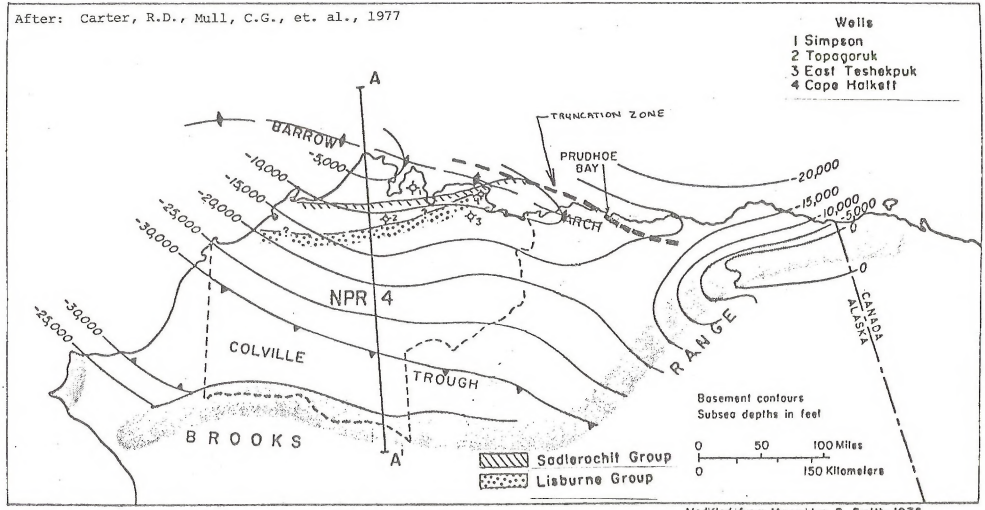
Potential reservoirs in PBSA include all formations previously described, as well as some carbonates in what is considered "basement". Exploration is expected to be costly in this area because of the complex stratigraphic and structural relationship which appears to control the hydrocarbon accumulation, and the increasing depth of known producing horizons south of Prudhoe Bay. The major structural elements of North Slope geology and a generalized cross-section from the Brooks Range to Prudhoe Bay are shown in Figures 5, 6, and 7.

Two additional oil fields have been discovered in the PBSA. The Kuparuk River formation, just west of the Prudhoe Bay field, may contain as much as 1 billion barrels of oil at relatively shallow depths of about 6,000 feet. Atlantic Richfield Company (Arco) plans to drill two or three development wells during the 1977-78 winter season on leases it holds approximately 6 miles west of the Prudhoe Bay field. The formation is composed of much thinner sands than the Sadlerochit formation, and is scattered over an area 40 miles long and 20 miles wide, "with some bald spots", according to a State petroleum geologist.

If the first wells are successful, they will be the first of a planned 32-well development program costing an estimated $230 million, with delivery of 60,000 to 80,000 barrels of oil per day from the Kuparuk to the Trans-Alaska pipeline expected to begin in 1981. Drilling began in the fall of 1977 as soon as an all-weather road was completed and drill sites were constructed. A gravel causeway and temporary bridge will be built across the Kuparuk River to the drill site, which is located about 30 miles west of Arco's Prudhoe Bay base camp. The Kuparuk development will require its own camp and service facilities independent of the Prudhoe Bay Field.

Another large Paleozoic, Cretaceous, and/or Tertiary oil and gas field, with low gravity oil, is developing about 50 miles east of Pump Station 1 on the Trans-Alaska pipeline (Fig. 8). Exxon has drilled two successful oil and gas wells on an east-west trend at the edge of the Beaufort Sea and is preparing to drill a third about 4 miles to the west. In addition, Arco has applied to drill a wildcat (Mickelsen Bay State 1) east of Prudhoe Bay and about 24 miles west of Exxon's recent Point Thompson Unit #1 discovery well.

The two discoveries, which Exxon just announced, are about 8 miles apart and have similar characteristics; but also have some very important differences. According to the Oil and Gas Journal (Ref. 13), the Flaxman



Modified from Morgridge & Smith, 1972

FIGURE 5 – TECTONIC ELEMENTS OF THE NORTH SLOPE OF ALASKA

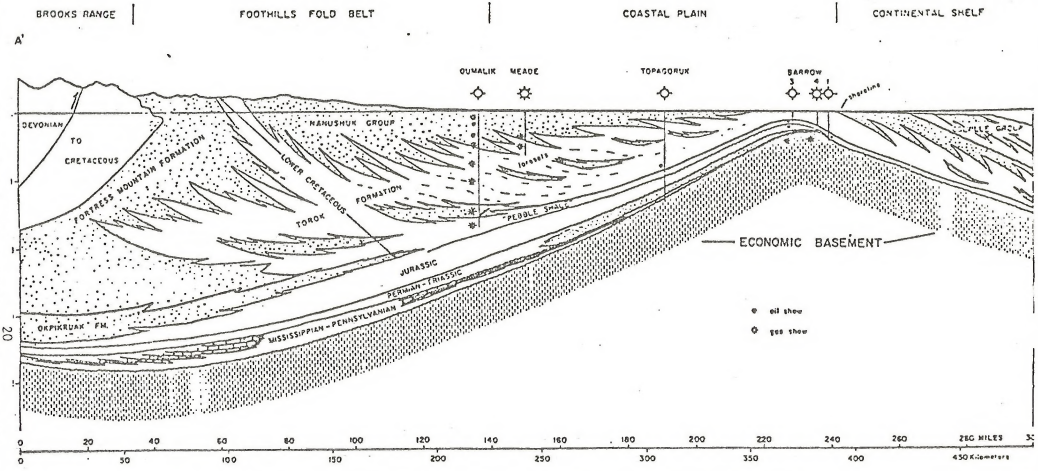


FIGURE 6 – DIAGRAMMATIC STRUCTURAL-STRATIGRAPHIC CROSS-SECTION A'-A, NPRA

After: Carter, R.D., Mull, C.G., et. al. 1977

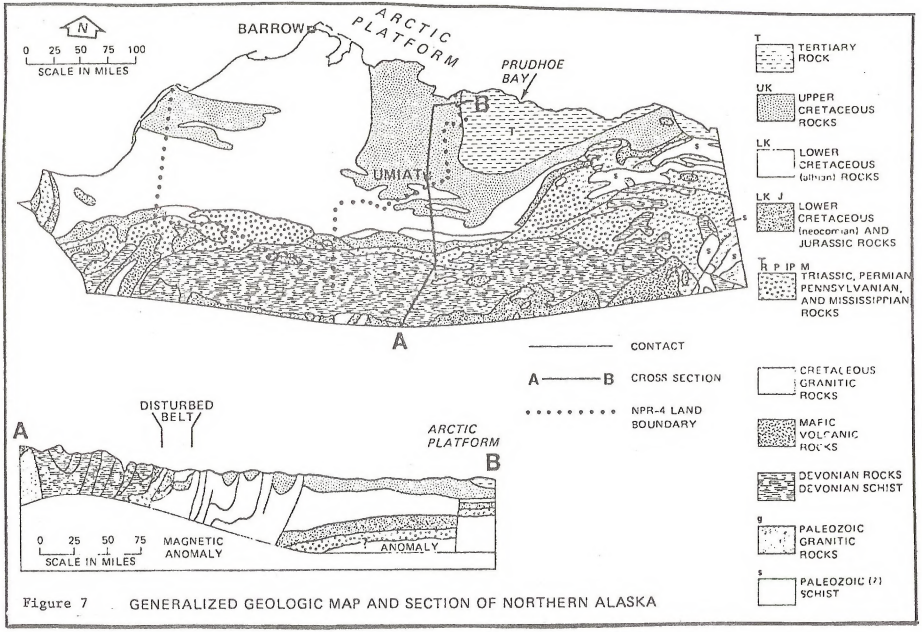


Figure 7 GENERALIZED GEOLOGIC MAP AND SECTION OF NORTHERN ALASKA

After: Dept. of Navy, 1977

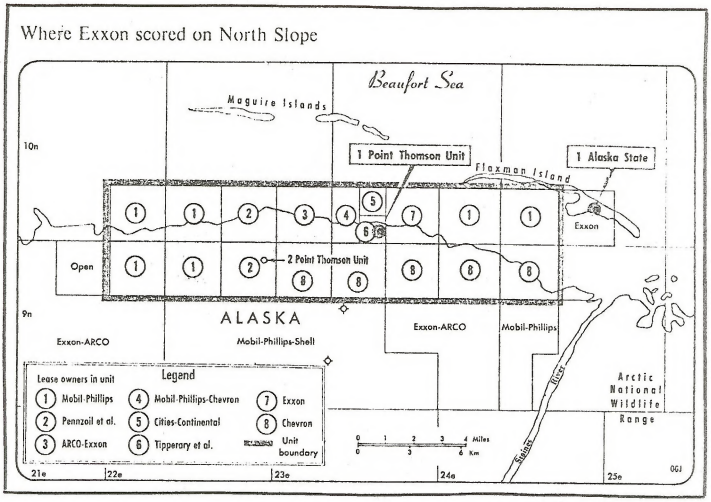


Figure 8

From: The Oil and Gas Journal
November 14, 1977

Island well flowed about 2,500 barrels per day of 23.1° gravity oil and more than 2 mmcfd of gas from 12,565'-610' and 12,620'-635'. The Point Thompson well flowed at about 2,300 barrels per day of 18.5° gravity oil and 13.3 mmcfd of gas from 12,963'-13,050'. The Point Thompson well, therefore, has a much higher gas-oil ratio and its producing horizon is deeper than the Flaxman Island wells. This could imply, among other things, the existence of two distinct fields in the area.

One Exxon executive is quoted as saying, "We are seeing, so far, just the tip of the iceberg, but we must continue to probe to see just how big it is. Potentially, it is a good-sized field. That's what you must have to build a 50-mile pipeline on the North Slope." (Ref. 13).

Exploration and development is expected to continue in the PBSA, especially along the Beaufort Sea coastline. Such activity may ultimately result in a pipeline and gravel haul road system along the Beaufort Sea coastline from ANWR to the NPRA and farther.

Central North Slope Area

The Central North Slope Area (CNSA), as described by the State of Alaska (Ref. 7) is located south of Prudhoe Bay and southeast of NPRA, and extends over portions of the coastal plain, northern and southern foothills, and the Brooks Range (Fig. 4).

Gibson and Kerschner (Ref. 7) have, with the assistance of various State geologists, described this area as follows:

> "As would be expected for an area that includes a variety of geologic and geographic provinces, the properties of the geologic formations in the region change considerably. The units at the surface in the disturbed belt and the Brooks Range are known to be considerably different than those mapped and drilled north of these areas.
>
> Anticlinal structures present north of the disturbed belt are believed to be decollement in nature (Figure 3.8.1-2). Decollement structures can be compared to the wrinkles produced in a blanket as it is slid across a table top. Here the folded Cretaceous are believed to have slid along the surface of the Torok Shale. Most of the area covered by this report is included in the area of decollement. Therefore, no surface anticline may be presumed to extend at depths below the thick Lower Cretaceous Torok Formation. Evidence for the decollement is given by Brosge and Tailleur (p. 92), who state: 'According to available seismic data, the folds in the Albian Nanushuk Group do not affect the base of the Cretaceous, which dips regionally southward from the Barrow Arch.' The 1965 geologic map of Lathram (USGS Open File 254) shows many structures mapped at the surface. (Figure 3.8.1-3). In the area covered by Quaternary and Undifferentiated map units, additional structures are probably present in the sub-surface and most could be identified by seismic interpretation."

Due to the excessive depth (20,000' to 30,000') of the Colville Trough (Fig. 5 and 6), existence of decollement structures, a decrease of sand content and porosity to the south, and the apparent absence of the unusual stratigraphic and structural relationships which are the controlling factors responsible for the Prudhoe Bay field, additional large Prudhoe Bay type fields are unlikely in this area.

Although another Prudhoe Bay appears unlikely in this area, the existence of relatively small oil fields such as Umiat, and gas fields such as Gubik and Kemik warrant further exploration.

Arctic National Wildlife Range

The onshore area with perhaps the greatest potential for having another Prudhoe Bay type oil and/or gas field is the Arctic National Wildlife Range (ANWR) (Fig. 4).

The State of Alaska (Ref. 7) states, "the Lisburne Group, Sadlerochit and Shublik formations, Colville Group, and Tertiary rocks all have good reservoir characteristics and have potential in the ANWR." They further state that the stratigraphic and structural relations prevalent at Prudhoe Bay may extend into the area. Also the Cretaceous unconformity present at Prudhoe Bay may extend into the area and truncate potential reservior units on the 46 mile long Marsh Creek anticline. This large structure has been estimated to contain up to 14 billion barrels of oil in four prospective horizons.

A recent hydrocarbon evaluation of the ANWR was prepared by Gil Mull and B.A. Kososki of the USGS for the U.S. Fish and Wildlife Service (Ref. 10). This excellent report, which describes the geology and anticipated resources of the range, subjectively rates the range into the following four categories:

I. Very highly prospective
II. Moderately prospective
III. Slightly prospective
IV. Non-prospective

The data does not enable quantitative estimates to be made and only permits delineating areas with approximate boundaries based on interpretation of currently available data.

The data reviewed by Mull and Kososki indicate the presence of extremely rich source beds, beds with excellent reservoir potential, reservoir sealing beds, and structural traps in part of the ANWR. The data included gravity and magnetic information which was used to delineate shallow structures showing synclinal and anticlinal axis, faults, strikes and dips, geologic contacts, and depth to basement contours.

Interpretation of all data indicates that the area with the highest hydrocarbon potential, referred to as "extremely high" by Mull and

Kososki (page 7) underlies the Arctic Coastal Plain in an area extending from Barter Island on the north and southward between the Jago River and Okpilak River to approximately latitude 69°50'N. The following evidence indicates that this area could possess the same hydrocarbon resource potential as Prudhoe Bay:

1. Extremely rich source beds. Geochemical analysis of shale from Jago River revealed 9.5 percent organic carbon and 3,820 ppm oil content; (Ordinary nonsource shales have less than 100 ppm oil content);
2. Regional trends indicate that the Sadlerochit and Lisburne Group sediments improve in reservoir character northward, similar to Prudhoe Bay reservoir potential;
3. The Kemik Sandstone Member of the Kongakut Formation may also have reservoir potential in the subsurface;
4. Area is underlain by a large structurally high platform onto which the sedimentary rock units thin;
5. A deep sedimentary basin, in excess of 25,000 feet, in the vicinity of Camden Bay;
6. Similar deep sedimentary basins offshore to the northwest, north, and east of Barter Island;
7. Prominent circular drainage pattern on the Niguanak River;
8. Area displays very nearly the same regional patterns as the Prudhoe Bay area; and
9. Presence of oil seeps at Manning Point and near Angun Point, and a large outcrop of oil saturated sandstone on the Jago River.

In summary, the area south and east of Barter Island has extremely high potential for containing significant hydrocarbons. The need for regional reflection seismic profiles is necessary to determine the actual subsurface relationships so critical to the development of possible hydrocarbon accumulations.

The other area with moderate potential lies beneath the northern part of the Coastal Plain and Foothills area between the Canning River and Barter Island. Although this area contains rich source beds, potential reservoir beds, at least one large anticline (Marsh Creek), and oil saturated sandstones in outcrop, it is not considered as highly prospective as the Barter Island area to the east. This is primarily due to the excessive depths to some of the favorable reservoir horizons and the resultant impact upon the porosity and oil generating capability. The Marsh Creek anticline may be a very shallow feature that does not affect deeper stratigraphic horizons. Also, some of the best potential reservoir beds may be absent in this area.

Within a realistic time frame, exploration and development of ANWR could be accomplished in such a way as to retain the highly valued wilderness aspects of the foothills and mountainous terrain of the core area to the south.

Beaufort Sea and Chukchi Sea Outer Continental Shelf

The Beaufort Sea, according to various USGS, State, and industry geologists, possesses the greatest potential for another Prudhoe Bay type oil and gas field than any other area in northern Alaska, with the possible exception of the ANWR Coastal Plain.

Brosge' and Tailleur (Ref. 2, page 98) describe the potential of the offshore prospective rocks as follows:

> "The Upper Cretaceous Colville Group thickens markedly seaward above the basal unconformity at Simpson Seeps, and the Tertiary is inferred to overlie the Colville disconformably and also to thicken abruptly offshore north of the Sadlerochit Mountains. The Colville marine shale is a probable source of oil. The upper Colville and possibly the Tertiary are probable sources and reservoirs for gas. Exploration offshore may find great thicknesses of Colville Group or Tertiary marine rocks and may find oil or gas either within these rocks or directly below the unconformity."

This prediction has since been strengthened by recent major oil and gas discoveries by Exxon offshore on Flaxman Island, and by Dome Petroleum Limited in the Canadian Beaufort Sea (Ref. 13, 11, and 12).

One of Dome's discoveries, known as K-59 Nektoralik, was drilled 109 miles northwest of Tuktoyaktuk Peninsula and approximately 100 miles east of the Alaska/Canada border (Fig. 9). The well flowed medium gravity oil at rates up to 1,150 barrels per day and reportedly encountered an extensive Tertiary gas zone at 8,000 feet. Dome officials were quoted as saying, "the well indicates the Canadian Beaufort could contain 20 trillion cubic feet of natural gas". The C-50 Ukalerk, another Dome test well 48 miles north of Tuktoyaktuk, flowed gas at rates of up to 16.9 mmcfd.

The existence of Tertiary oil and gas in the Canadian Beaufort, oil seeps and oil sands in Tertiary outcrops in the ANWR Coastal Plain, and the possiblity of finding oil and gas accumulations in older Paleozoic and Mesozoic rocks along the Barrow Arch makes the shallow water nearshore portion of the Beaufort-Chukchi OCS a prime target for future exploration.

Development of near shore OCS oil and gas will be greatly influenced by the economics of exploration, development drilling platforms, and pipelines. Many industry, State, and Federal petroleum engineers and geologists feel that the present day technology is adequate for development in the shallow, shore-fast ice portions of the Beaufort and Chukchi Seas.

OCS drilling costs will vary significantly and will be directly related to the type of required drilling platform, gravel availability, and an exceptionally long list of environmental considerations. For example,

Dome's Beaufort Sea discoveries

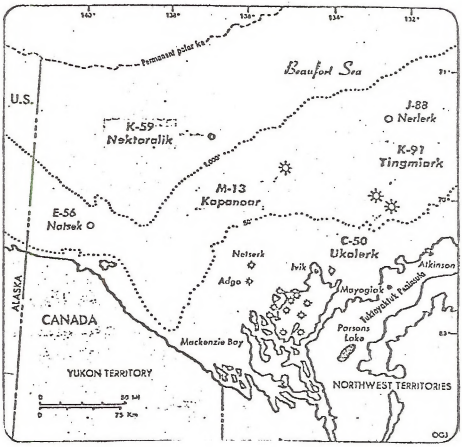


Figure 9

the artificial island, Netserk B-44, which was constructed in 15 feet of water in the Canadian Southern Beaufort, cost $11 million. Conversely, the Helca N-52 well was drilled in 421 feet of water in the Canadian Arctic Islands for a total cost of $2 million, of which $.5 million was used for prepartion of an ice platform (Ref. 3).

It is estimated that ice island construction generally costs about $2.5 to $5 million dollars in Canada. This figure may be higher in the U.S. Beaufort because of environmental constraints in dredging and hauling material.

Perhaps the most important factor in OCS development will be availability and use of gravel and/or soil for artificial islands, causeways for gathering lines, barge loading and unloading facilities, and onshore support facilities. If gravel is not available, quarry stone from the Brooks Range, or man-made tetrahedrons, may be required. A lack of gravel may dictate that ice islands be utilized for exploration drilling and some other method, other than artificial islands, be used for development drilling. Other methods include:

1. floating rigs, which only have a 2.5- to 3-month working season (this season may be extended to nearly 12 months utilizing large icebreaker assistance such as that proposed by Dome Petroleum Company of Canada);
2. reinforced ice platforms, which limit the depth to which a well can be drilled in one season (cost estimated at less than $5 million);
3. ballasted barges with gabion or sandbag contained silt berm or sea ice thickening for protection from waves and ice;
4. ice strengthened drillships;
5. gravity structures in deeper water where artifical islands are not feasible;
6. monopod variety of gravity structure;
7. cone-shaped drilling platform; and
8. semi-submersible drilling rigs which are in the conceptual or design stages.

The choice of which drilling method to use will be dependent upon water depth, ice conditions, depth to the producing horizon, distance from nearshore support facilities, environmental considerations including gravel availability, and the overall objective of minimizing cost. Each prospect or field will have to be evaluated on a site specific basis to determine its economic viability and optimum development program.

Economic Factors

Some of the factors which influence oil and gas economics in northern Alaska are:

1. type, size, and physical characteristics of the fields;
2. transportation systems;
3. accessibility;
4. Federal and State leasing policies;
5. wellhead price and pipeline tariffs;
6. available markets;
7. port capacities;
8. environmental and technical stipulations and regulations; and
9. communications.

The following statements and figures concerning some of these factors were obtained from various Federal and State agencies and several oil and gas industry personnel.

Type of Field

Three of the most important factors in evaluating oil and gas field economics are size, depth, and physical characteristics of the field. For example, one of the major oil companies in Alaska recently quoted the following figures for two different scenarios on the North Slope:

	Case 1	Case 2
Field Depth	7,000'-7,5000'	10,000
Recoverable Reserves	425 MMBO	130 MMBO
Cost of Production Facilities Without Pipelines	$350 million	$150 million
Distance From Prudhoe		
50 miles	economic	economic
50 to 100 miles	marginal	marginal
over 100 miles	not economic	not economic

A comparison of case 2 to 1, reveals the following differences: (1) recoverable reserves in case 1 are three times greater than in case 2, and (2) cost of production facilities for the shallow field are greater than for the deeper field in case 2. This is because deeper fields can generally be produced by drilling a greater number of deviated holes from a single location. Also, deeper fields usually require less drill sites, access roads, and gathering facilities.

Another important factor in determining field economics is whether the field is onshore, offshore, or in a transition zone such as the Sagavanirktok River Delta.

In Cook Inlet, where processing and shipping facilities are essentially adjacent to the producing facility, the minimum economic field size is much smaller than on the North Slope. For example, an industry rule of thumb for Cook Inlet production is:

1. 35-50 MMBO to be economic offshore
2. about 10 MMBO to be economic onshore
3. 50 BCFG may be economic onshore

Comparison of these figures with the two previous North Slope scenarios reveals that minimum economic field size for onshore North Slope fields is more than 10 times greater than in Cook Inlet. Also, the relative size of the offshore fields to onshore fields is expected to be as great, if not greater, on the North Slope because of adverse technical and environmental conditions. This conclusion was substantiated by the Alaska OCS Office in their evaluation of the Beaufort Sea (Ref. 3, page 98). Their economic analysis, based on current USGS estimates, indicates insufficient reserves in the Beaufort Sea to justify a new oil or gas pipeline. Consequently, Beaufort Sea oil or gas might have to be transported by tanker or by utilizing spare capacity in existing lines.

FEA Assessment of NPRA

The Federal Energy Administration (FEA) stated in their assessment of NPRA (Ref. 6) that a minimum size field of 460 MMBO, recoverable, would be required to allow the nation as a whole to realize an 8 percent discounted rate of return on the required investment. They further stated, "Minimum field size could vary from 280-930 MMBO." This again points out the fact that minimum field size increases drastically with distance from Prudhoe Bay, especially if utilization of the existing Trans-Alaska Pipeline Systems (TAPS) is assumed.

FEA stated that analysis of the preliminary data indicates no massive structures with reserve potential similar to Prudhoe Bay but that there are the following structures:

Estimated Field Size	Number of Structures
greater than 550 MMBO Equivalent Capacity	9
250-500 MMBO " "	11
100-250 MMBO " "	26

The FEA derived nine different scenarios with three different wellhead prices for oil/gas production from NPRA. These scenarios, and other northern Alaska scenarios are discussed in detail in section II of this report.

In general, their analysis indicates that a 500 MMBO field in NPRA gives a positive Net National Economic Benefit at $13/barrel. However, they stated, "royalty payments and taxes would burden private operations and it would be unprofitable to develop."

In consideration of present day economics and with evaluations based on preliminary geological data, it is possible that much of NPRA, WAA, and the Beaufort Sea may not contain economic deposits of oil and gas. However, this will depend largely on the success, if any at all, in eastern NPRA and along the Beaufort Sea coastline, future advancements in oil and gas technology and transportation methods, and future prices for oil and gas.

Water and Gravel Availability

Other parameters, such as the physical characteristics of the oil and gas, reservoir characteristics, maximum allowable production rate, pay zone thickness, secondary and tertiary recovery methods and costs, and availablity of water and gravel, are equally important in evaluating the economics of oil and gas fields in northern Alaska.

Water and gravel availability and use will be critical factors in determining whether or not a field can be developed. According to the State of Alaska (Ref. 7) water and gravel is relatively scarce in the western part of the North Slope except along the Colville and Ikpikpuk Rivers. However, fish concerns and/or (d)(2) legislations may prohibit gravel removal from either river. Lack of, or inability to use, existing resources will definitely hinder, if not prevent, exploration and development of the anticipated, relatively small and isolated oil and gas deposits in the WAA and western NPRA.

Even areas which contain previously approved gravel sites with remaining material, along the Alyeska pipeline, are now being viewed as detrimental to fish concerns. Therefore, the 130,000 to 180,000 cubic yards of gravel which it takes to build a Hercules strip, or even the 20,000 to 30,000 cubic yards for a Twin Otter strip, may be unobtainable.

Water and gravel resources are relatively more abundant to the east, especially in the ANWR where large Prudhoe Bay type structures are anticipated. Unfortunately, in order to preserve what has been referred to as "the last unspoiled wilderness area in the world" no development of any kind, including an accurate appraisal of recoverable resources, has been permitted in this area. This could actually result in an unwarranted amount of environmental disturbance throughout the remainder of northern Alaska. Such disturbance would result from attempts to develop the relatively smaller, generally isolated oil and gas fields anticipated in the interior portions of northern Alaska. In the long run, the sanctity of a very minimal portion of the ANWR, where other Prudhoe Bay type structures are anticipated, may not be worth the unnecessary additional environmental stress imposed upon the remainder of the North Slope.

Recently, in view of an increasing awareness of energy requirements in the lower 48 states, Congressman Seiberling amended House Bill H.R. 39 to include a five-year Federal seismic exploration program and possible exploratory drilling in the Arctic National Wildlife Range. The overall

effect of this accelerated exploration program may be environmentally detrimental to the existence of the Porcupine caribou herd. This adverse impact was emphasized in a letter to Congressman Seiberling from Mr. Walter Parker of the LUPC. In that letter he stated, "A less than intensive exploration program within a five-year period is not likely to obtain information of value for making long-term determinations on development of the coastal plain. The main point I am making is that the short time constraint as imposed in your amendment will probably be environmentally detrimental rather than protective. To me, it is far better that the time be extended for a period which will allow the Secretary of the Interior to coordinate this exploration with other development including Canadian development along the Arctic Coast so as to minimize the total impact in any one time period."

Evaluation and development of Alaska's oil and gas resources is vital to the well-being of Alaska as well as the entire nation. However, timing of this process is more critical if development of Arctic resources is to be accomplished in a manner that minimizes negative impacts, maximizes economic returns and insures sufficient uniform protection for the entire Arctic area.

Drilling Costs

Drilling costs are extremely variable and significantly greater in the Arctic than in the lower 48 states, or even southern Alaska.

Drilling costs naturally depend on the accessibility, depth, type of well, (straight or deviated, exploration or development), amount of casing and drilling mud, and the extent of the logging and testing program. For example, considering a winter operation in a remote area, with no road construction, a 7,000-foot onshore wildcat well would cost about $6 million. An additional $3 million would be required for a full testing and casing program if the well contained economic quantities of oil and/or gas. A 10,000-foot well under the same conditions would cost about $11 million. These costs would naturally be less near the Prudhoe Bay area where there is an existing road and transportation system.

Arco plans to spend about $200 million for 32 wells to develop the Kuparuk River sands in the Prudhoe Bay area. These are shallow wells (6,500') that will be drilled from 4 pads at an average cost of $6.25 million. In comparison, according to an industry development geologist, the average development well in the Prudhoe Bay field costs about $3 million. This again emphasizes the drastic escalation in exploration and development costs with increased distance from Prudhoe Bay.

A large portion of this increased cost is attributed to availability of gravel and associated costs of access roads, work pads, and drill site construction. This conclusion is evident when one compares the $182 million budget authorized for the 1977-78 nine-well drilling program in NPRA. Their program consists of two deep wells (19,000+'), two medium wells (± 10,000'), two shallow wells (4,000'-5,000'), and three develop-

ment gas wells for Barrow. Costs will be significantly greater for the deeper wells because of a required two-year drilling program; however, this amounts to an average of about $27,830,000 per well if the three Barrow gas wells (estimated at $5 million each) are not considered. This relatively high cost is related to isolation of the area, limited gravel sources, and other technical and environmental concerns.

Transportation Costs

Much of the drilling equipment and supplies are transported to NPRA and other areas on the North Slope by Hercules C-130 cargo planes. For example, a drill rig with drilling mud and chemicals, weighing between 1.5 and 2 million pounds, was flown from the Foran well site to Drew Point. This particular move required 162 trips with the Stretch Hercules at about 50,000 pounds maximum per load (Ref. 1).

Other large freight items which must be moved either by air or Rolligon are fuel and water. According to the NPRA FEIS (Ref. 5), it takes 500,000 to 600,000 gallons of fuel to drill one medium depth well. This would require about 85 to 100 trips with a Rolligon or 100 flights with the Hercules. A normal fuel storage on site of 70,000 gallons is required to furnish a 10-day supply.

The other large freight item is water. It takes approximately 1,000 barrels of water per day in the early stages of drilling. Later on, this figure reduces to an average of 600 barrels per day for 60 to 70 days, which is required for a medium depth well.

Offshore Drilling

Offshore drilling costs in the Beaufort and Chukchi Seas will be substantially greater than the onshore drilling costs. This depends, to a large extent, upon gravel availability and type of required drilling facilities.

The gravel required to build a 3-acre exploratory drilling island, in 30 feet of water with 10 feet of freeboard is 200,000 cubic yards. A 7-acre production island would require 450,000 cubic yards (Ref. 3). As an alternative, ice islands, some of which cost more than $5 million, could be used for exploratory drilling. This essentially eliminates the need for gravel but limits the depth that wells can be drilled in any one season.

Exploratory wells, which are being drilled in the Gulf of Alaska where sea ice presents no complications, are averaging about $110,000 per day per well; with a total cost of $17 to $20 million per well. Platform costs in the Gulf of Alaska, which vary significantly as water depth increases, are also a significant item in determining economics. The following data are estimates of platform costs obtained from a development geologist from a major oil company in Alaska.

200' water	$ 85 million
400' water	$150 million
600' water	$235 million

The State Division of Energy (Ref. 18) stated, "company sources indicate that an oil field in the Gulf of Alaska must be expected to yield 100 to 150 million barrels before development platforms would be built."

Pipelines

As previously stated, distance from existing transportation systems, including pipelines, haul roads, seaports, airports, and oil and gas treatment facilities is probably the next most important criteria in determing oil and gas field economics. A prime example of this is the estimated additional one billion barrels of oil anticipated in the Kuparuk River sands, which Arco plans to develop just west of Prudhoe Bay. These anticipated reserves would most likely not be economical if the Trans-Alaska pipeline were not already in place. This is especially true considering the relatively thin pay zone, the large area involved (16 sections), and the cost of access roads, 4 drilling pads, and 32 development wells.

As was demonstrated on the Alyeska oil line, pipeline construction in the Arctic can be very costly. The cost of this 800-mile-long pipeline was nearly $8 billion for an average of $10 million per mile. This figure includes all pipeline, haul road, pump station, and terminal construction costs.

If additional capacity is not available in the existing Trans-Alaska oil pipeline and the proposed Alcan gas line, field size of future oil and gas discoveries must be large enough to accommodate additional cost of either another type of transportation system or looping of the existing lines. The cost of looping the existing oil line would probably be much less than the $10 million per mile average because the existing haul road, pump stations, and construction pad could be utilized.

Pipeline construction costs by themselves can vary drastically depending on items such as pipe size, whether it is buried or elevated, and type of terrain. Ed Patton of Alyeska recently quoted (Ref. 14) the following figures concerning a few of the representative pipeline construction costs associated with TAPS:

Cost of aboveground support system (VSM's) = $1.1 billion.
Cost of increased system capacity (.5 MMBO/D to 1.2 MMBP/D) = $.7 billion.
Haul road construction = $300+ million.

Bob Huck (Ref. 8), former Senior Engineer with the State Pipeline Coordinators Office, tabulated the following pipeline construction costs. The figures, which include costs for pipe, freight, bedding and padding, and gravel work pad are:

	Mountains	Hilly	Level
36"	$3,800,700/mile	$2,921,045	$2,671,988
42"	$5,236,013/mile	$3,355,873	$3,042,516
48"	$5,836,192/mile	$3,902,332	$3,533,977

Comparison of these values with pipeline construction costs for the lower 48 states (Fig. 10) reveals that Arctic pipeline construction costs are as much as 10 times greater than in the lower 48 states.

This substantial increase in arctic construction costs applies to all construction projects in Alaska and is not unique to the TAPS project. For example, a 70-mile, 10-inch, 8-inch, and 6-inch fuel products pipeline was constructed from Nikiski to Anchorage during 1976. That relatively simple pipeline cost approximately $22 million for an average cost of $314,285/mile. This is comparable to lower 48 construction costs for 36-inch diameter line (Fig. 10).

Accessibility

As previously stated, if Congress does not institute remedial legislation, some possible problems can be anticipated for any future oil and gas lines as a result of (d)(2) lands legislation. The primary problems, which may hinder or completely halt any pipeline construction, is gravel extraction and the crossing of rivers which are under consideration for inclusion into the Wild and Scenic River System. This is particularly true in the WAA and NPRA.

Other Factors

Other factors such as wellhead price, pipeline tariffs, environmental stipulations and regulations, and Federal and State leasing policies also have an impact on the economics of oil and gas.

Two factors which have a large impact upon oil and gas economics are market availability and port capacity. Even if additional pipeline capacity is available in the TAPS, further development in northern Alaska will be very dependent upon port capacity at Valdez and availability of west coast or other markets.

Another factor, which will have a significant impact on future oil and gas development, is adoption of regulations and stipulations for northern Alaska oil and gas operations and pipeline construction. For example, during public hearings on the State of Alaska's proposed pre-leasing program, Paul Norgaard of Atlantic Richfield Company stated, "these regulations are calculated to discourage rather than encourage further exploration and development in the State." Since that time, the Alaska Division of Minerals and Energy Management has revised its proposed new Multiple Land Use permit regulations and will reportedly schedule public hearings on the new proposals in early April. The latest draft of the regulations is considerably shorter and appears to lack some of the controversial portions which drew opposition earlier.

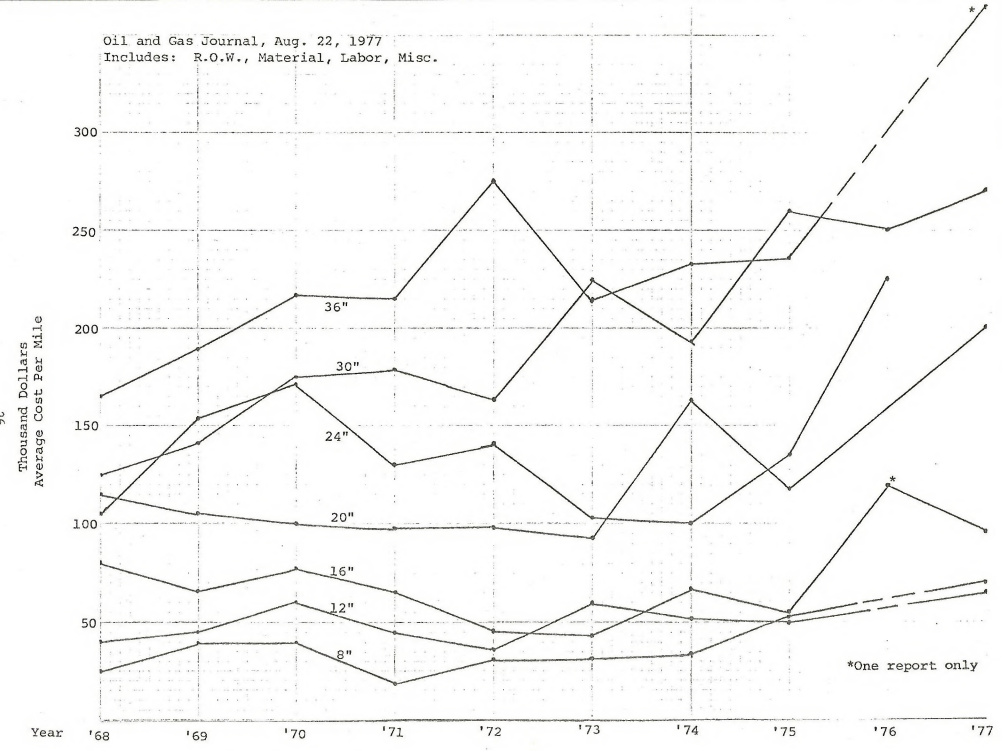


FIGURE 10: Ten Year Onshore Construction Cost Trend

The Department of the Interior conducted a TAPS critique session in August, 1977, in Anchorage, Alaska. The purpose of the session was to determine the effectivness of Alyeska and governmental monitoring agencies during construction of TAPS and to discuss methods for improving work quality on the natural gas line. In general, the critique session was beneficial in that it summarized most technical, environmental, socio-economic, and labor related problems encountered during the TAPS project. However, several specific comments and details relating to controversial topics, such as gravel removal from the Sagavanirktok River, were somewhat misleading and could, if interpreted incorrectly, impede or totally block further construction projects in Alaska.

An additional work session is recommended prior to drafting a new set of environmental and technical stipulations and regulations for pipeline construction. It is further recommended that the resulting joint Federal, State, and local government regulations and stipulations pertain to, and be equitably enforced, on all construction and development projects throughout the entire State. This will help to eliminate application of "double standards" by government monitoring agencies.

A joint Federal, State, and local government exploration, development, and transportation plan should be adopted to insure adequate and equitable protection for all areas and concerns in the Arctic. Once such a plan is adopted, it could ideally be expanded into an international operating and development agreement with Canada. This would offer the greatest opportunity for protecting the entire Arctic region, while allowing reasoned, well-planned growth. Such an international operating agreement with Canada appears inevitable in view of recent exploration success offshore from the Mackenzie Delta and in the Arctic Islands.

A joint oil spill prevention and clean-up agreement between Alaska and Canada is of particular importance to Arctic development, especially in view of peculiarities of the Beaufort Sea ice pack. The polar ice pack, north of the Mackenzie Delta and beyond the continental shelf, moves in a clockwise direction due to the stationary high pressure air mass over the Canada Basin. This circulation, called the Beaufort Gyre, circulates the ice in a slow westward movement and completes a cycle every ten years or so (Ref. 17, page 19). As a result, any oil spilled in the Canadian Beaufort Sea and Arctic Islands will eventually have an impact upon the Alaska coastline.

The Canadian government is acutely aware of the problems associated with clean-up of oil spills on, under, and in sea ice, and is actively involved in developing new methods for prevention and clean-up of oil spills in the Arctic. To complement the Canadian work, it is recommended that the United States obtain more data pertaining to oil spill containment and clean-up at sea and on the beaches, ice migration, weather, interactions of oil with sea ice, and locating and tracking oil spills under harsh Arctic winter conditions. Such data is necessary to insure development of the Beaufort Sea hydrocarbon resources in an environmentally sound manner.

OIL AND GAS DEVELOPMENT SCENARIOS

Introduction

This is a summary of various Northern Alaska oil and gas development scenarios derived by the Federal Energy Administration (FEA); the Bureau of Land Management (BLM), Outer Continental Shelf Office (OCS); and the Alaska Division of Minerals and Energy Management (DMEM).

The primary objective of the report is to briefly outline some of the anticipated impacts from oil and gas development in Northern Alaska. Although somewhat speculative, the scenarios present a viable starting point for future transportation and socioeconomic studies which must provide for ever increasing economic, environmental, and aesthetic concerns.

The basic oil and gas development parameters and anticipated results are presented in tabular form for the FEA (Plate 1) and State of Alaska (Plate 2) scenarios. However, complexity of the OCS scenarios precluded presentation in tabular format, and only the more pertinent items are highlighted.

FEA Scenarios for NPRA

In view of continuing dependence upon imported oil, the Naval Petroleum Reserves Production Act (NPRPA) of 1976 authorized exploration of NPRA to define more precisely the amount of resources that can be developed.

To fulfill requirements mandated by Section 164 of the Energy Policy and Conservation Act (EPCA), FEA decided to retain Resource Planning Associated, Inc. (Cambridge, Massachusetts) and two subcontractors, LaRue, Moore, and Schafer (Dallas, Texas) and Dames and Moore (Anchorage, Alaska), to assist in compilation of information and editorial suggestions for a comprehensive study of NPRA. The resulting document (Ref. 6) contains several important preliminary conclusions concerning exploration and development requirements, management and land use programs, and socio-economics and environmental impacts.

Four major conclusions on issues and areas related to exploration requirement resulted from the study.

1. Resource Estimates

   The FEA stated, "A more recent, informal USGS estimate of 2-8 billion barrels of oil and 7-25 trillion cubic feet of gas appears more reasonable." This somewhat optimistic figure, especially for oil, has since been revised by several knowledgeable USGS geologists to as little as 1 to 3 billion barrels of oil.

2. Geologic Structures Distribution

There is no indication of a massive structure with reserve potential similar to Prudhoe Bay. However, there are numerous smaller structures with the following estimated capacities:

Estimated Oil-Equivalent Capacity	Number of Structures
500 million barrels	9
250 to 500 million barrels	11
100 to 250 million barrels	26

3. Minimum Field Size

A minimum field size of 460 million barrels of recoverable oil would be required to allow the nation as a whole to realize an 8 percent discounted rate of return on investment. Furthermore, the minimum field size necessary for economic development could vary from 280 to 930 million barrels of oil.

4. Exploration Programs

Case 1: If NPRA was as productive as reservoir assumptions indicate: It would take 111 exploratory wells to maximize NNEB in this case. This would result in capital requirements estimated at $1.3 billion and 2,000 man-years for a NNEB of $3.9 billion.

Case 2: Minimum size field is found in each zone:
This will require 103 wells, capital requirements of $1.5 billion, and over 2,100 man-years.

Case 3: Discouraging results:
This requires 13 wells at $182 million capital requirement and with 300 man-years.

To develop rate and resource requirement estimates, the contractor developed nine scenarios representing 3 field sizes; 500 million, 1 billion, and 3 billion barrels of oil equivalent; and three different market prices; $10, $13, and $16 per barrel. Four conclusions resulted from analysis of these scenarios and other development related factors:

1. Development and Production Activity

Peak production would be nearly 100,000 barrels per day (64 wells) for the 500-million-barrel scenario, nearly 200,000 barrels per day (128 wells) for the 1-billion-barrel scenario, and nearly 600,000 barrels per day (378 wells) for the 3-billion-barrel field.

2. Capital Costs

On an undiscounted basis, capital costs for development would range from $1.7 billion for the 500-million-barrel field, to $2.5 billion for the 1-billion-barrel field, and $5.3 billion for the 3-billion-barrel field.

3. Manpower Requirements

Peak manpower needs for field development and pipeline construction for all field sizes occur in the fourth year after discovery; with the 500-million-barrel field requiring peak direct employment of approximately 1,500, the 1-billion-barrel field requiring 2,400 employees, and the 3-billion-barrel field requiring nearly 5,000 employees.

4. Net National Economic Benefits

The net national economic benefits vary widely for the nine scenarios evaluated.

- The 500-million-barrel field at a $10-per-barrel world price is the only nonprofitable development scenario.
- A 1-billion-barrel field would create benefits ranging from $0.7 to $3.3 billion.
- A 3-billion-barrel field would result in significantly larger benefits, ranging from $4.9 billion to $12.9 billion, depending on world oil prices.

Additional conclusions of the Federal Energy Association study are:

1. Development of NPRA will be influenced by: boundary disputes between Federal and State agencies, land settlements, availability of corridors and public easements, and development of other North Slope petroleum provinces. For example, two separate boundary disputes now being contested in NPRA could slow the pace of development. First, the dispute over whether the Colville River bed is within or outside the Reserve could delay using its critical gravel resources to construct access roads, camps, and other development-related facilities. Second, the dispute over whether the Arctic coast boundary of the Reserve is the highest high-water mark or mean high-water mark, and the inclusion or exclusion of certain bays in the Reserve could delay exploratory drilling in Harrison Bay and other promising bays along the coast.

2. Overall, FEA favors private sector exploration, development, and transportation activities in NPRA for reasons of efficiency.

3. With a 500-million-barrel field and $13 oil, there is a positive net national economic benefit with NPRA development. However, the field would probably not be developed by the private sector under

conventional leasing arrangements. Royalty payments and taxes would burden the private operator to the extent that it would be unprofitable to proceed with development.

4. To make NPRA development reasonably profitable to the field developer, who would have to assume the cost of using the Trans-Alaska Pipeline System (TAPS) and constucting a spur line to TAPS, some of the institutional barriers will have to be relaxed.

5. There is no consensus, even among the Natives, on whether the net economic, social, and environmental impacts of NPRA development are advantageous or adverse.

6. An appropriate State of Alaska and local government compensation program, preferably through existing government programs, should be devised.

7. Development of NPRA could have a moderate to large impact on the State's population and employment, depending upon field size.

8. With NPRA development, the fiscal impacts on the State would vary significantly, depending on whether private or government development occurred. Under private development, the State would realize fiscal gains of at least $150 million with a 3-billion-barrel field. Under a complete government-development scenario, the State, if uncompensated by the Federal government, could suffer a net fiscal loss (infrastructure costs in excess of net State revenues) of about $40 million for a 500-million-barrel field, a loss of nearly $160 million for a 3-billion-barrel field.

9. About half of the development-related population increase is estimated to occur in Anchorage; 15 percent in Fairbanks; and the remainder in other parts of the State.

10. The issues of greatest concern to the Natives are:

    a. would development interfere with surface resources;
    b. camp location; and
    c. what restrictions, if any, would be imposed on nonresident, temporary workers.

11. Under five of the scenarios, given existing institutional arrangements, the profitability of NPR-4 development to the private developer is highly uncertain. Although net benefits to the private sector as a whole would be positive, expected benefits to the field developer would be negative. To make NPR-4 leasing attractive to private developers, not currently involved in North Slope operations, the Federal government may have to relax existing pipeline tariff procedures and, to a lesser extent, fixed royalty requirements.

12. State employment impacts range from 4,000 jobs (peak year) for a 500-million-barrel field to 13,000 jobs (peak year) for a 3-billion-barrel field.

13. Under private development, the State would realize no net fiscal impact for a 500-million-barrel field, a gain of $151 million for a 1-billion-barrel field, or a gain of $473 million for a 3-billion-barrel field.

14. Population impacts in the North Slope Borough would likely range from 500 to 2,400 people over the range of assumed discoveries.

15. Local government cost increases could range from $30 million to $120 million for the three assumed scenarios; local revenues were not estimated.

In conclusion, the comprehensive study required by Section 105(b) of NPRPA requires the President to direct appropriate Executive departments, and/or agencies, in consultation with the State of Alaska, to conduct a study to determine the best overall procedures for the development, production, transportation, and distribution of petroleum resources in NPRA, and the economic and environmental consequences of each. The study should consider pipeline utilization, access to pipelines, mechanisms for setting TAPS and other potential pipeline tariffs, and alternate leasing procedures and other Federal actions that facilitate private sector development of NPRA.

Periodic progress reports are required. A final report, with recommended procedures and any proposed legislation, is to be submitted to the Committees on Interior and Insular Affairs of the Senate and the House of Representatives not later than January 1, 1980.

State of Alaska Scenarios

The State of Alaska Division of Minerals and Energy Management (DMEM) prepared a comprehensive petroleum development study (Ref. 7) to provide a more refined picture of anticipated industrial development on the North Slope.

This study, which consists of 21 individual scenarios and 2 combined scenarios (Plate 2), presents basic information to the policy makers who must evaluate development alternatives and overall impacts of petroleum development, including economic, social, and environmental impacts.

To facilitate scenario development, the North Slope was divided into the following five distinct activity areas (Fig. 4):

1. National Petroleum Reserve in Alaska (NPRA)
2. Western Arctic Area (WAA)
3. Prudhoe Bay State Area (PBSA)
4. Central North Slope Area (CNSA)
5. Arctic National Wildlife Range (ANWR)

Each scenario, presented in Plate 2, was comprised of an evaluation of natural resources, such as sand, gravel, and water; petroleum related facilities and activites, such as exploratory wells and seismic activity; pertinent legal statutes; geology; environmental constraints; land status; and regulations. Two combined scenarios, not included in Table 2 because of their complexity, were prepared to show the effects of development in various areas on the entire North Slope. Refer to the original document for a detailed synopsis of each scenario, including location maps, information summary sheets, and peak workforce profiles.

The first combined North Slope scenario (NS-1) shows the result of massive exploration with no permanent facilities constructed and no commercial fields discovered. The individual scenarios incorporated to make this scenario are: PBSA-1, PBSA-6, NPRA-1, NPRA-4, CNSA-1, WAA-1, ANWR-1, ANWR-4. The Prudhoe Bay offshore sales in 1979 and 1983 were delayed ten years. As can be seen in the Peak Workforce Profile (Fig. 11), the maximum number of people needed to carry out these exploration activities is significantly less, although the duration of the activity is longer, if the lease sales are held at the later date rather than the earlier one. Refer to Table III for details of the lease dates and water consumption.

The NS-1 exploration programs result in 176 wells, the majority of which are in submerged lands. There are 37 wells in the offshore PBSA, 39 off NPRA, and 14 off the ANWR. Onshore, there were 20 wells drilled in the Prudhoe Bay Area, 35 within NPRA, 15 within CNSA, and 16 in WAA.

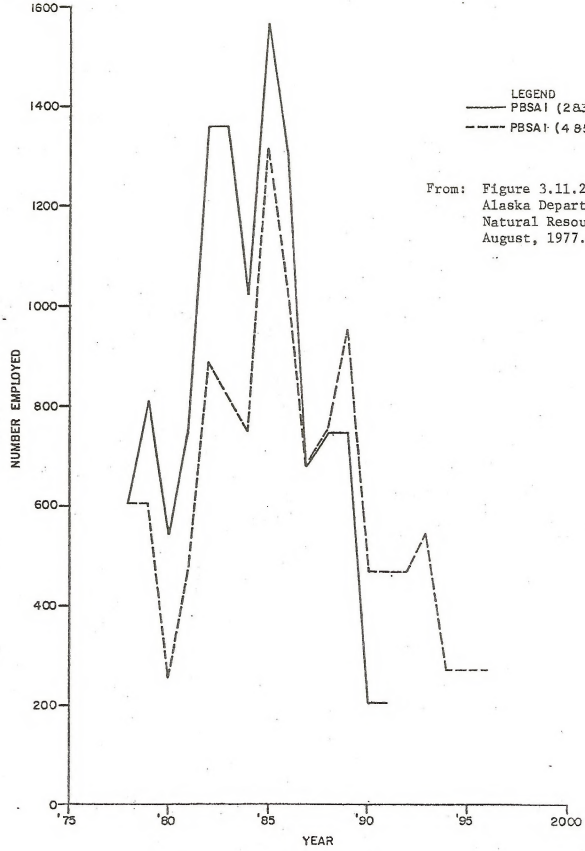
The second combined scenario (NS-2) assumes combined production in millions of barrels as shown in Table IV, with a resulting peak workforce profile as shown in Figure 12. The data reveals that this scenario would result in a production of 5.06 billion barrels of oil equivalent, and a peak work force of about 6,800 people in 1997-1998.

Alaska Outer Continental Shelf Office Scenarios

The Bureau of Land Management and the Alaska Outer Continental Shelf Office prepared a detailed study of the socioeconomic and environmental impacts of Beaufort Sea petroleum exploration, development, and production (Ref. 3).

This study, which included manpower, equipment, and material requirements; scheduling of petroleum development; and technical, environmental, and economic concerns, was prepared in support of the proposed Federal OCS Beaufort Sea lease sale.

To accomplish this study, fifteen different scenarios representing five levels of discovered reserves and three different arbitrary locations between the 3-mile limit and the 20-meter isobath, were generated (Figs. 13, 14, 15 and 16). The scenarios were then evaluated for their economic feasibility under differing economic assumptions.



From: Figure 3.11.2-1
Alaska Department of
Natural Resources,
August, 1977.

FIGURE 11 - PEAK WORKFORCE PROFILE: NS-1

AREA	LEASE DATE
PBSA-2	1979
PBSA-3	1983
PBSA-4	1989
PBSA-5	1993
PBSA-6	1985
NPRA-1	1981 & 1985
NPRA-4	Not Applicable
CNSA-1	1977
WAA-1	1977
ANWR-1	1987
ANWR-4	No Exploration Allowed

Peak Worforce Profile. Figure 2.1.1-2

Water (in millions of gallons)

Personal Consumption:	128.8
Drilling:	358.8
Total Water:	487.6

From: Table 2.1.1-1
Alaska Department of
Natural Resources,
August, 1977.

TABLE III

NS-1

INFORMATION SUMMARY

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
PBSA-2								1.4	23.9	41.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	41.6	33.3	26.6	21.3	17.0	14.5
PBSA-3											1.4	23.9	41.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	41.6	33.3	26.6
PBSA-7													2.0	11.0 2.0	18.0 11.0	24.0 18.0	24.0 24.0	24.0 24.0	24.0 24.0	24.0 24.0	24.0 24.0	23.8 24.0	19.0 23.8
NPRA-2															1.4	23.9	41.8	43.8	43.8	43.8	43.8	43.8	43.8
NPRA-3																		2.0	11.0	18.0	24.0	24.0	24.0
NPRA-5										4.5	39.5	70.0	73.0	73.0	73.0	73.0	73.0	73.0	73.0	69.4	55.5	44.4	35.5
NPRA-6															1.4	23.9	41.8	43.6	43.8	43.8	43.8	43.8	43.8
NPRA-7																2.0	11.0	18.0	24.0	24.0	24.0	24.0	24.0
CNSA-2					1.4	23.9 2.0	41.8 11.0	43.8 18.0	43.8 24.0	43.8 24.0	43.8 24.0	43.8 24.0	43.8 24.0	43.8 24.0	41.6 23.8	33.3 19.0	26.6 15.2	21.3 12.2	17.0 9.7	14.5 7.8	12.3 6.6	10.5 5.6	8.9 4.6
WAA-2										1.4 2.0	23.9 11.0	41.8 18.0	43.8 24.0	43.8 24.0	43.8 24.0	43.8 24.0	43.8 24.0	43.8 24.0	43.8 23.8	41.6 19.0	33.3 15.2	26.6 12.2	21.3 9.7
ANWR-2																1.4	23.9	41.8	43.8	43.8	43.8	43.8	43.8
ANWR-3																						4.5	39.5
TOTAL					1.4	25.9	52.8	63.2	91.7	117.5	187.4	265.3	296.2	309.2	325.6	373.9	436.7	457.1	458.8	444.1	413.2	381.3	383.0

TABLE IV
NS-2
COMBINED PRODUCTION IN MILLIONS OF BARRELS

From: Table 3.11.3-2
Alaska Department of
Natural Resources,
August, 1977.

From: Figure 2.1.2-2
Alaska Department of
Natural Resources,
August, 1977.

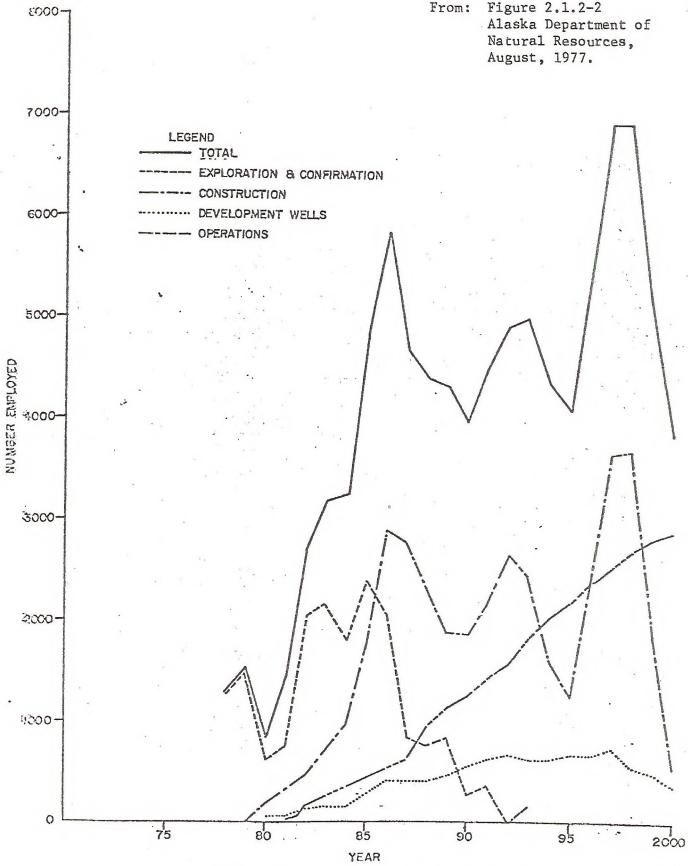
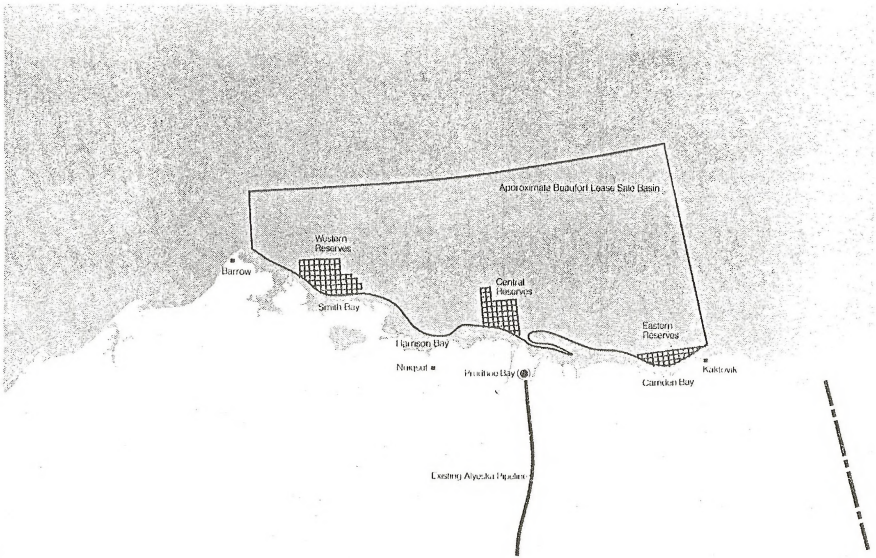


FIGURE 12 - PEAK WORKFORCE PROFILE: NS-2



Selected Petroleum Development Scenarios:
Hypothetical Locations of Reserves

Figure 2-2

FIGURE 13

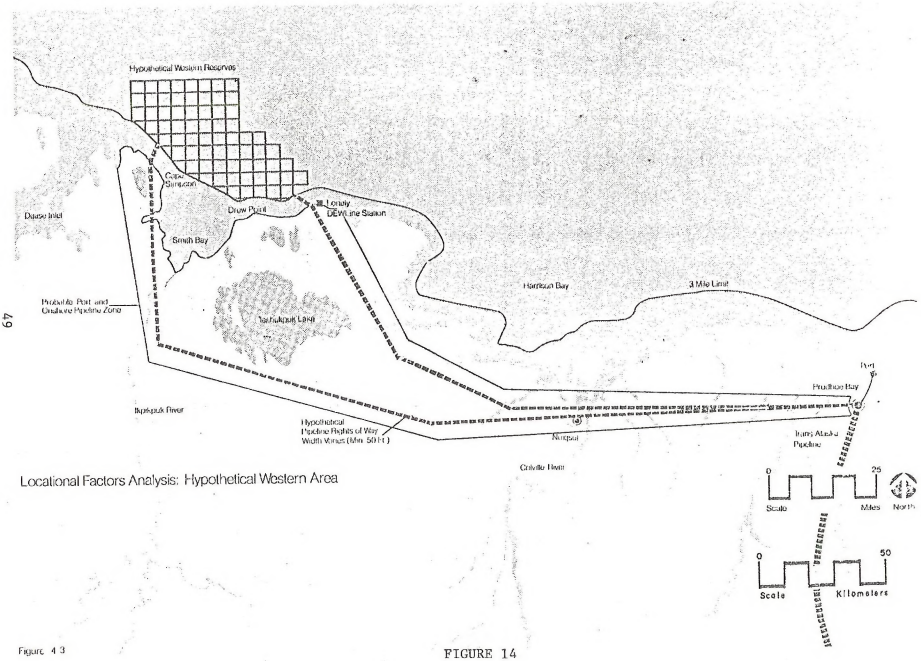


Figure 4 3

FIGURE 14

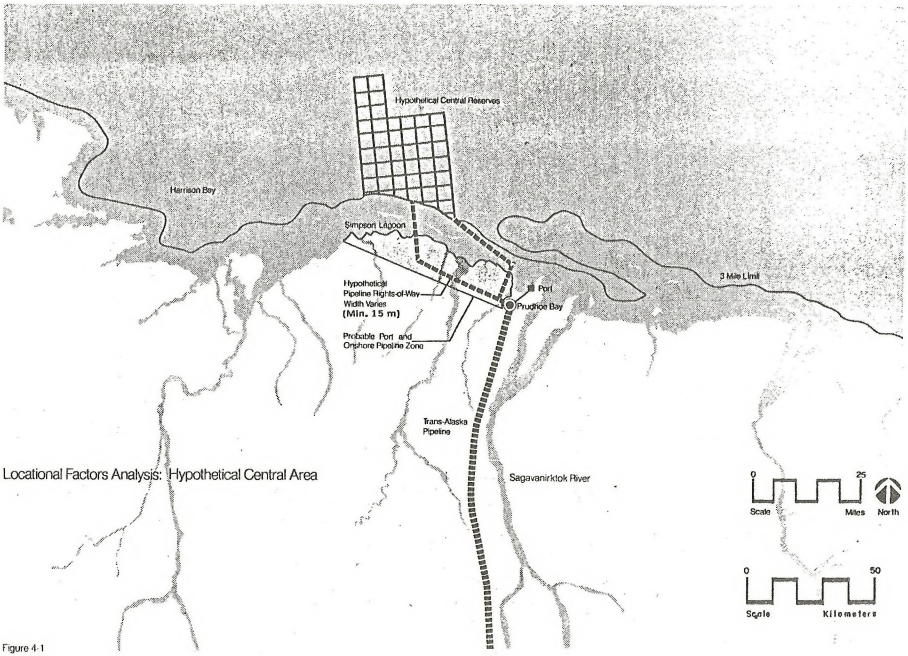


Figure 4-1

FIGURE 15

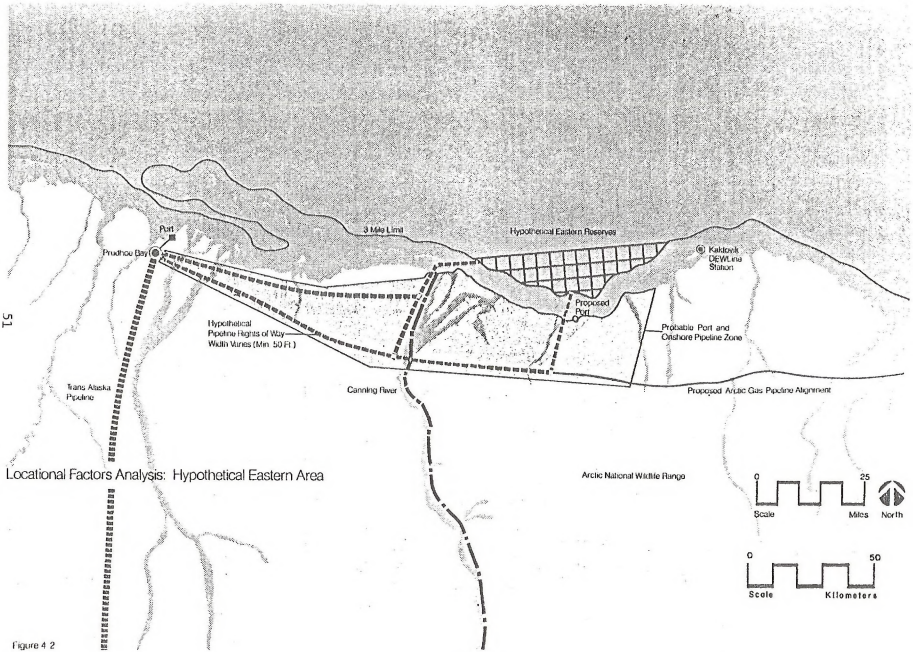


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Figure 4 2

FIGURE 16

The economic assumption and the parameters which were analyzed for the 15 scenarios are:

1. Reserve Size: 3.5 Bbbl, 2.3 Bbbl, 1.4 Bbbl, 0.7 Bbbl, 0.4 Bbbl
2. Location of Discovery: east, central, west
3. Exploration Activity: optimistic, cautious
4. Investment Cost: high, low
5. Effective Producer Tax Rate: 35%, 10%
6. Desired Rate of Return: 25%, 20%, 15%, 10%, 5%
7. Gas Transportation Tariff: new line; high primary, low tariff on shared existing line
8. Most Feasible Market Price: $12, $13, $14 per barrel for oil, and $6, $7 per unit (2.5 mcf) for gas (constant 1975-76 dollars)
9. Limit Market Price: $17 per barrel for oil and $10 per unit for gas (constant 1975-76 dollars)
10. Numbers and types of offshore platforms and wells
11. Logistics
12. Manpower and construction activities
13. Pipeline and transportation requirements and specifications
14. Onshore facilities and structures
15. Time schedules

Capital cost assumptions for the Beaufort Sea OCS scenarios were derived using 1975-76 millions of dollars price base.

CAPITAL EQUIPMENT	ESTIMATED COST (millions of dollars) Low	High
Tract Costs (each)	5	10
Exploration Platforms:		
Gravel/Reinf. Earth Islands (each)	8	15
Drillships/Rigs (each) (1)	3	11
Ice/Earth-Ice Islands	2	5
Production Platforms:		
Gravity Structures @ 50 ft. (each) (2)	35	65
Gravity Structures @ 20 ft. (each)	20	40
Gravel Island @ 15-25 ft. (each)	15	30
Exploratory Wells (each):		
First 6 per exploratory region	10	15
Remainder	5	8
Production Wells (each):		
First 20 per field group	8	10
Remainder, including development wells:	3	6
Processing Equipment (per MBD Capacity) (3)	0.5	0.7
Gas Plant (per 100 mmcfd) (4)	10	14
Transportation:		
Barges (each)	0.7	1.2
Supply Vessels (each)	0.2	0.2
Supply Tractors (each)	0.1	0.1

	Low	High
Harbor (each)	4	6
Crew Base (each)	8	12
Roads:		
Long Roads (per mile) (5)	0.35	0.4
Short Roads (per mile)	0.25	0.3

	Low Cost Flow Rate in MMBD			High Cost Flow Rate in MMBD		
	(.1-.4)	(.4-1.0)	(1.0+)	(.1-.4)	(.4-1.0)	(1.0+)
Oil Pipelines:						
Offshore (per mile)	8	8	10	8	9	12
North Slope (per mile)	7	8	9	7	9	11

Gas Pipelines (per mile): Estimated at 70% of oil pipeline costs for equivalent flow rates.

Environmental constraints, such as sea ice and its movements, oil spills, availability and use of borrow material, impacts of dredging and erosion were also considered in the scenario development. Technical concerns including ice scour, subsea permafrost, temperature, wind, waves, storm surges, logistics, and platform design were accounted for in the economic analysis.

For the 15 scenarios and the Federal OCS lease sale discussed in the report, the following USGS estimated undiscovered recoverable oil and gas resources were used:

Oil (billions of barrels)	0 to 3.9
Gas (trillions of cubic feet)	9 to 9.9

The following statistics and conclusions were based on the above USGS estimated resources:

Field Size (BBO)	# Producing Wells Required	Maximum Flow Rate Per Day	Average # of Production Wells/Platform
3.5	440	1.10MMBO/1.3BCFG	37
2.3	295	0.7MMBO/0.9BCFG	37
1.4	180	0.4MMBO/0.46BCFG	38-40
0.7	90	0.2MMBO/0.3BCFG	45
0.4	50	0.1MMBO/0.15BCFG	50

Additional graphs of assumed number of tracts purchased and developed, assumed production profiles, gravel requirements, pipeline specifications, oil spill probabilities, and various economic analyses are included in

Chapters II and III of the OCS report. Table 3-4 (pages 169 to 174 of OCS report) and Tables 3-5A to 3-9C list the exploration costs by reserve level, activity level, cost level, and the development sumaries for the five basic field sizes.

In general, the OCS report concluded that there are, "insufficient oil and gas reserves (based on current USGS estimates in the Alaskan Beaufort Sea) to justify a new trans-Alaska oil or gas pipeline." Consequently, Beaufort Sea oil and/or gas might have to be transported by utilizing spare capacity on existing pipelines, or by some other means of transportation. Furthermore, it is conceivable that gas reserves in other areas will be discovered first and will contract for the expanded capacity in the proposed gas line.

Table 3-14A to 3-14P (pages 221 to 235) is a tabulation of the required market price for Beaufort Sea scenarios. From these tables, the OCS office concluded (page 236), "It is evident that production delay is costly, and that no investor could be expected to profit by holding the gas for delayed delivery."

Comparison of the minimum field development sizes (Tables 3-15A, B, and C) reveals the economic advantages of discovery in the central location. Under high-cost investment requirements and under high-tax conditions, the minimum size field needed to achieve a 10 percent return on investment is 0.35 Bbbl in the central location, 1.0 Bbbl in the eastern location, and 2.3 Bbbl in the western location. This is a direct consequence of the required pipeline mileage to the interconnection with the Alyeska line.

Four scenarios were selected for more detailed analysis and to furnish a hypothetical chronology of development activities, manpower requirements, and scheduling and facility requirements.

The four selected scenarios are as follows:

Scenario No. 1 - Exploration only in all three geographical locations (western, central, and eastern Beaufort Sea) based on a low reserve estimate (95% probability).

Scenario No. 2 - Development in Prudhoe Bay based on a mode reserve estimate (50% probability).

Scenario No. 3 - Development in Camden Bay based on a high reserve estimate (5% probability).

Scenario No. 4 - Development in Smith Bay based on a bonanza reserve estimate (2% probability level).

Chronology of major events and facility requirements are described in detail in Chapter IV of the OCS report.

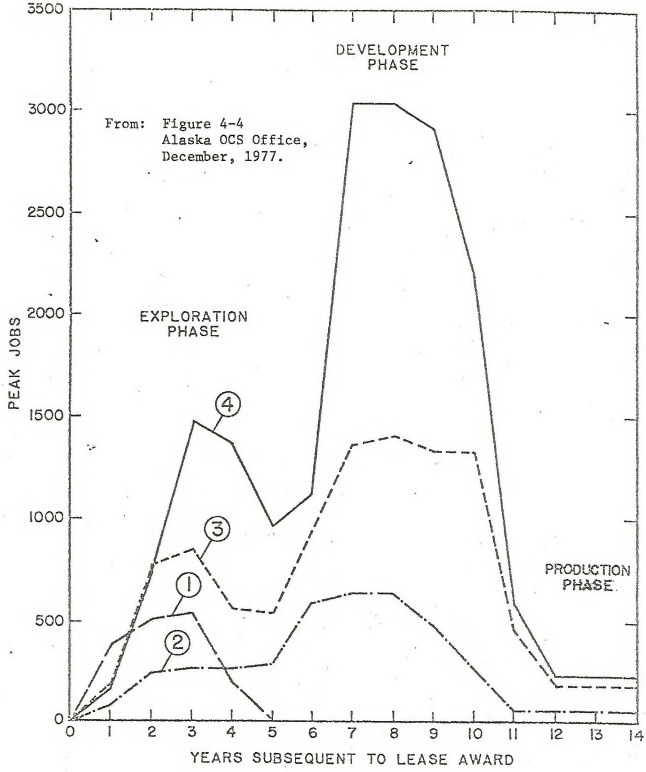
A comparison of the respective manpower requirements for the four selected scenarios is shown in Figure 17. This comparative manpower graph shows that the four scenarios follow very similar patterns from the time of the lease award to the start of production, which represents a period of approximately 11 years. The level of manpower moves through two distinct cycles corresponding to the phases of exploration and field development. The exploratory cycle lasts for five years, reaching a peak in the third year; and the developmental cycle lasts for six years, reaching a peak in the seventh and eighth years after the lease award.

Selected facts for the four scenarios are:

Items	Scenario			
	#1	#2	#3	#4
Tracts Explored (total)	8	4	20	40
Reserves Discoverd (Bbbl)	0	0.7	2.3	3.5
Pipeline (total miles)	0	45	130	275
Production Wells (total)	0	103	343	516

From all the above information, the OCS office concluded that, during the development phase, total manpower requirements are directly related to: (1) number of production wells, and (2) miles of pipeline. In turn, the number of wells drilled is a direct function of the amount of oil discovered; and the miles of pipeline a direct function of the distance to Prudhoe Bay for link-up with Alyeska. By placing the largest amount of oil at the greatest distance from Prudhoe Bay (scenario number four), the two significant relationships concerning manpower were compounded. As a result, although the amount of oil in scenario number four is 150 percent of that in scenario number three, the relative manpower required during peak development (year eight) is over 200 percent greater for scenario number four.

One of the significant conclusions to arise from the manpower analyses of the four scenarios is the large percentage of unskilled workers required during the exploration phase (about 45% of the total) contrasted with the large percentage of semi-skilled workers required during the development phase (about 55% of the total). This is principally due to the skills required for pipeline workers combined with the disproportionate share of the work force they comprise during the development phase. One of the major implications is that employment opportunities for local, unskilled labor are greatest during the early years of OCS activity.



COMPARATIVE MANPOWER REQUIREMENTS
FOR FOUR SCENARIOS
(PEAK JOBS PER YEAR)

FIGURE 17

RESOURCE POLICIES

Introduction

This is a brief summary of various Federal, State, and local government policies and concerns related to oil and gas development in northern Alaska.

At the present time, existing Federal policies for development of onshore northern Alaska hydrocarbon resources, pertain primarily to the NPRA. These policies, which resulted from the Energy Policy and Conservation Act, Public Law 94-163, December 22, 1976, and the Naval Petroleum Reserve Production Act of 1976 (P.L. 94-258), are mandated by law to consider the aspects of development as they pertain to NPRA, and not to the entire North Slope. Although such studies are necessary, final recommendations should include influencing factors in adjacent lands, both onshore and offshore.

Federal policies which pertain to the OCS portion of northern Alaska were established by the OCS Lands Act. This act, according to the President's Energy Program, would be amended to require a more flexible leasing program using bidding systems that enhance competition, to assure a fair return to the public, and to assure full development of OCS resources.

State and local government policies are being proposed which are designed to insure against significant adverse effects or impacts on significant subsistence or other traditional or cultural land, sea, or ice users by residents of the region.

The Inupiat recommendation to deal with the Beaufort Sea as a single ecological system in which all offshore operations would be held to a single set of international rules appears reasonable. Furthermore, their policy to oppose all Arctic OCS operations until safe and responsible extraction technology can be designed and tested is compatible with the intent of all other Federal, State, local government, and Canadian policy for the Arctic.

FEA Recommendations and Conclusions

The Naval Petroleum Reserves Production Act (NPRPA) mandates Government exploration of the Naval Petroleum Reserve Number 4 (NPR-4), but does not authorize development or production of petroleum discoveries. Although maximum private sector involvement in NPR-4 exploration, development, and production is preferred, private industry will not be interested in exploring NPR-4 without assurance of the right to develop and produce any discoveries.

The following recommendations were submitted to the Committees on Interior and Insular Affairs of the Senate and the House of Representatives in

compliance with Section 164 of the Energy Policy and Conservation Act (EPCA), as amended by Section 105(a) of NPRPA.

1. The comprehensive study required by Section 105(b) of NPRPA should begin immediately, with resulting findings and recommendations presented to Congress by June 1, 1977, if possible, but in no event later than January 1, 1978.

2. The study required by Section 105(b) of NPRPA should consider, as appropriate, pipeline utilization, access to pipelines, and mechanisms for setting tariffs for TAPS and other potential pipelines, as well as alternative leasing procedures and other Federal actions that facilitate private sector development of NPR-4. Confirmation of the amount of excess TAPS capacity is important in estimating the benefits from exploration and development of NPR-4.

   Further study of the institutional constraints to petroleum transport from any finds in NPR-4 is warranted.

3. The Department of Interior should prepare to request statutory authority to lease NPR-4 to private industry as soon as is practicable. Private industry exploration and development are desired and are considered more efficient than government involvement. However, it is doubtful that a single operator, whether it is government or a single oil company, is capable of mounting the multiple-perspective exploration approach that, historically, has been successful in finding oil and gas. Statutory authority to lease will be required before industry participation in NPR-4 can be realized, since the industry will not be interested in exploration unless there is assurance of the right to develop any petroleum finds.

   Under a limited government exploration program, the government would drill in the most promising spots over the next 3 years, freely disseminate these findings to all potential bidders, and proceed with the necessary leasing to the private sector as soon as legislation is obtained. By thus reducing the investment risk for the private sector, the government would increase both bidding competition and probability that excess profits, if they occur, would be transferred to the public sector.

   In addition, some fields that are not profitable for the private sector to develop would nevertheless show a net national economic benefit for development.

4. A government exploration program should be continued during the period required to implement a leasing program.

5. The Federal government should consider ways to assure that State and North Slope Borough governments are assisted in offsetting negative net economic impacts resulting from NPR-4 development.

Section 107(b) of NPRPA directs the Secretary of the Interior to assist Alaskan communities adversely affected by exploration activities through the use of existing Federal programs. An appropriate compensation program, preferably through existing government programs, should be devised.

6. Appropriate measures for mitigating potential adverse environmental and socioeconomic impacts should be implemented.

7. In all matters pertaining to the exploration, development and production of NPR-4 petroleum resources, the Department of Interior should work closely with the various agencies of the State of Alaska.

   Close coordination of Federal policies with the interested State agencies is especially important in the Department of Interior's preparations for leasing to private industry and in the planning and implementation of measures to mitigate any adverse environmental, social, or economic impacts on the State of petroleum-related activites in NPR-4. State concerns should be addressed explicitly as part of the NPRPA study and the leasing process.

8. Periodic progress reports are required, and a final report with recommended procedures and any proposed legislation is to be submitted to the Senate Committee on Energy and Natural Resources and the House of Representatives Committee on Interior and Insular Affairs not later than January 1, 1980.

   The apparent intent of the Congress in requiring both FEA's report under Section 164 of EPCA and the comprehensive study under Section 105(b) of NPRPA is that any further decision regarding the disposition of petroleum resources in NPR-4 should be based upon a thorough analysis of the available options.

9. Because NPR-4 is a public resource, the Federal government must ensure that any exploration and development of that area yield the maximum economic benefits to the nation as a whole, without producing unduly adverse environmental and socioeconomic impacts.

10. The extent to which the Federal government can use its power of eminent domain, by allowing public easements for pipeline corridors and roads across Native- and/or State-owned lands also will determine how rapidly development can occur. However, the government's right of eminent domain has been challenged; State and Native groups have indicated they will oppose, through court action, recent Bureau of Land Management rulings that permit floating easements for future transportation of resources.

11. Although not required by the EPCA, representatives of the State of Alaska were invited to participate fully in the study. The State, through its Department of Revenue and Department of Natural

Resources, accepted this invitation and has participated in the study to a limited extent.

12. Offshore oil and gas areas have been leased through bonus payment and royalty competition under the Outer Continental Shelf (OCS) Lands Act of 1953. Federally owned, onshore lands have largely been leased under the noncompetitive provision of the Mineral Lands Leasing Act of 1920. Although neither alternative is authorized under the NPRPA, Section 164 of the EPCA required the FEA to consider such leasing alternatives.

    A myriad of other leasing arrangements, including competitive bidding on a bonus or royalty basis, profit sharing, and work plan competition have been examined. Calculations were made to determine the relative net national economic benefits and ultimate oil recovery realized by the various leasing methods. The major conclusion drawn from this quantitative analysis is that any method employing a declining royalty will yield greater net national economic benefits and higher ultimate oil recovery than a fixed royalty system, due to the tendency to abandon declining production under the latter system.

13. An extremely important issue in the determination of whether or not to develop the oil and gas resources of NPR-4 is the potential effect all related activity would have on the economies of the State of Alaska and North Slope Borough, the culture and life-style of the Alaskan Natives who reside on the North Slope, and the unique environmental components within the Reserve. There is general agreement that the economic, social, and environmental impacts of NPR-4 development are important, but there is no consensus, even among the Natives, on whether the net effects will be advantageous or adverse.

Naval Petroleum Reserve Production Act of 1976

The development of the EPCA recommendations for NPRA was effected through a formal study, and while this study was being conducted, additional legislation affecting NPRA was passed. In April 1976, the NPRPA was approved by Congress and signed into law by President Ford. Seven provisions of the law are especially relevant:

1. Working with the Department of Interior, the Department of the Navy will continue exploration until June 1, 1977, at which time jurisdiction for such activity will be transferred to the Department of Interior. In effecting this transfer of responsibility, the Navy will cooperate with Interior.

2. Exploration near the Utukok River, the Teshekpuk Lake, and other areas designated by the Secretary of the Interior will include measures to protect surface values.

3. The Department of Interior will establish a task force composed of North Slope Natives, representatives of the State of Alaska, and Department of Interior officials to develop recommendations to Congress on the best uses for the lands contained in NPR-4, taking into consideration Native subsistence needs, wilderness, scenic, historical, and recreational values; fish and wildlife habitats; mineral potential; and other values of the lands (Section 105(c)).

4. Government exploration is mandated; however, development leading to production must be authorized by Congress.

5. The Department of Interior is required to provide natural gas to the government facilities located in Barrow and the Village of Barrow.

6. The Executive Department, in consultation with the State of Alaska, will study NPR-4 resource development, production, transportation, and distribution (Section 105(b)). They will provide periodic reports to the Congress and will present a final report (NPRPA study) with recommended procedures and any proposed legislation, no later than January 1, 1980.

7. The Secretary of the Interior is authorized to assist, through existing Federal programs, communities in meeting the cost of increased municipal services and facilities if he determines that unfair and excessive financial burdens are a direct result of exploration and study activities.

Other Policies

Other Federal, State and Borough policies and/or regulations which will have an impact upon hydrocarbon development in northern Alaska include the following:

1. U.S. Army Corps of Engineers environmental stipulations relating to nearshore areas and waterways.

2. Planning activities and specific regulations for bounded jurisdictions include those established for:

   A. Federal pipeline rights-of-way for NPRA and the Arctic National Wildlife Range. Pipeline rights-of-way through Federal lands must be approved by the Secretary of the Interior under the Mineral Leasing Act of 1920, as amended. Part of the application for pipeline rights-of-way requires a plan which addresses environmental and cultural issues, including requirements designed to control damage to fish and wildlife habitats, and to protect subsistence resources.

An Act with similar intent exists for natural gas pipelines. The Natural Gas Act empowers the Federal Power Commission to issue a "certificate of public convenience and necessity" for gas pipelines across Federal lands.

B. Pipeline rights-of-way across State lands between the Colville and Canning Rivers. Pipeline rights-of-way across State lands require approvals of the Department of Natural Resources and the Division of Lands. The Director of the Division of Lands may give preference to uses which will be of the greatest economic benefit of the State and to the development of its resources. For "distribution pipelines" and secondary roads, this action may proceed without prior approval of the Commissioner of Natural Resources.

The Alaska Right-of-Way Leasing Act, however, empowers the Commissioner of Natural Resources to review noncompetitive right-of-way on State lands. Requirements include the Commissioner's assessment of whether or not a pipeline would conflict with existing land uses, including subsistence.

C. NPRA exploratory and planning activities.

D. Arctic National Wildlife Range environmental stipulations.

3. Recommendations of the Alaska State/Federal Transportation Planning Organization which was established to consider transportation issues, policies and programs required by resource development and land selection and land use, leading to the development of State transportation plans.

4. Recommendation of the Alaska Coastal Management Program established by the U.S. Coastal Zone Management Act of 1972.

5. The North Slope Borough has instituted its own Arctic Coastal Zone Management Program (CZM) and is proposing to define a Borough and State legal position which would protect the rights of Inupiat Natives to subsistence areas beyond the 3-mile territorial limit.

6. Responsibilities for environmental protection for nearshore areas and waterways along with the Beaufort Sea coast and its navigable waters and streams are vested in the Department of Interior, the U.S. Army Corps of Engineers, the Environmental Protection Agency, and the Alaska Departments of Fish and Game and Environmental Conservation.

The Estuarine Area Study Act of 1968 and earlier statutes provide the Secretary of Interior with rights of protection of fish and wildlife resources from any activity or structure encroaching into coastal waters. This broad mandate could control the size and length of gravel causeways carrying offshore pipelines, the dredging

of barge channels, and the modification of rivers, bays, and lagoons would come under particular review.

7. Implications of the boundary dispute between the Federal and State governments over the redefined boundaries of NPRA which essentially assimilate potentially oil-rich submerged lands from the State of Alaska. The significance of this issue could affect pipeline alignments within these tideland areas.

8. Provisions of Section (d)(2) of the Alaska Native Claims Settlement Act which pertain to the Arctic National Wildlife Range. Specifically, the Department of Interior's proposed expansion of the Range to the south and west; establishment of additional restrictions for protection of Range values; and incorporation of the existing Range into the National Wilderness Preservation System (H.R. 39).

   Although this proposal has yet to be finally acted upon, its concerns will be reflected in any Interior decision regarding offshore or onshore OCS petroleum development activities centered in Camden Bay.

9. North Slope Borough's policy to protect the bowhead whale and the Beaufort Sea.

   The North Slope Borough policy was recently summarized by Mayor Eben Hopson (Daily News, December 23, 1977) who said:

> "To further protect the bowhead and the Beaufort Sea, it has been the North Slope Borough's policy to oppose all Arctic OCS operations until safe and responsible extraction technology could be designed and tested. The Inupiat want to deal with the Beaufort Sea as a single ecological system in which all offshore operations would be held to a single set of international rules. What happens in the Canadian Beaufort will affect us, and frankly, we are concerned with oil development taking place there now. The Arctic is without much margin for error. The North Slope Borough is seriously considering that the Beaufort Sea be recognized as a marine sanctuary.
>
> This past August, I testified at the d-2 hearing in Fairbanks and asked the Seiberling Committee to make the entire Arctic Slope a wildlife range with the exception of village selections of surface estate and the assorted DEW line sites. The only human activities that would be allowed would be those associated with natural resource extraction and traditional subsistence use.
>
> PUBLIC USE of the haul road has been opposed by the North Slope Borough. It is our policy to guard against permanent immigration to the Arctic. We are opposed to the creation of permanent oil field communities, and regard Arctic population

growth to be potentially our greatest environmental security problem. We oppose not only public use of the haul road, but also any other such permanent public access to the Arctic."

10. Arctic Region policies which are currently being proposed by the State of Alaska Division of Policy Development and Planning (State of Alaska MEMO, August 17, 1977.) These recommended policies are:

    A. Future development will not be sited on, within, or in destructive or disturbing proximity to areas of particular concern for historical, cultural, recreational, or dependence values.

    B. Future development will not create, nor likely result in, a demand for, or the construction of, any new permanent town or new community except where such new town or new community is in conformance with duly adopted State or local plans, zoning, ordinances and statutes; this policy is not, however, to discourage the construction and maintenance of support facilities and camps which are required to support resource development in this region.

    C. Installations required to basically support resource development in this region shall be designed and constructed either:

        (1) in such a way and at such places which will facilitate and make possible the easy and economically feasible removal of all buildings, structures and other installations when the development is ended; or

        (2) in such places and in such a way as to facilitate and make possible the easy and economically feasible conversion to other uses and needs which are described in duly adopted State, regional, and local land-use plans, industrial development plans, or similar governmental planning documents.

    D. New development will commence at a time and proceed at a pace which will not unduly burden required supporting goods, materials, services or facilities, private or public, including but not limited to transportation, communication, utilities, and local, regional, and State public infrastructure; and, in addition, at a time and place which will not have an undue detrimental effect upon existing commerce, industry, and development by excessive competition for, price inflation of, or dilution of quantity of such supporting goods, services, and facilities.

    E. New development of the land, sea, ice, and sea bottom resources of this region may only be accomplished by use of methods and areas which will insure that no significant adverse effects or impacts on significant subsistence or other traditional or

cultural land, sea, or ice uses by residents of the region; if such methods and areas are not now known, available, and economically feasible, then the resource development must be delayed until methods and areas which will insure acceptable results are developed, tested, available, and economically feasible; no resource development will take place which is likely to result in the genocidal destruction of one racial or cultural group of Alaskans for the benefit of any other group of persons.

F. It is the policy of the State of Alaska that all future resource development in the Arctic region must pay its own way to the net benefit of the people of the region and of the State; degradation, loss of subsistence and other resources, adverse economic, social, and cultural effects, increased burdens on services and facilities, attraction of and detriments from other developments, use of energy, and changes in life-styles and values of present Alaskans, as well as in monetary terms; benefits must likewise be measured in terms of increased employment opportunity for present Alaskans, improvements in quantity, quality, costs, or availability of housing, communications, transportation, health, education, increased net tax income, and the enhancement of desired cultural, social, and economic values of present Alaskans.

G. New development which requires, uses, consumes, appropriates, or diverts freshwater must not be sited, located, or developed unless and until the proposing developer or agency has clearly demonstrated to State and local authorities the fact that an adequate supply of freshwater of acceptable purity and quality is available without substantial adverse effects on:

1. the quantity or quality of freshwater required, planned, or reasonably anticipated to be required by reasonably expected growth, existing community, settlement, borough, or of other existing or planned developments in this region; and

2. the minimum adequate quantity and quality of freshwater which is required to support fish stocks, land or aquatic ecosystems, or wildlife which are important for the subsistence, culture, recreation, or economy of this region or of the State.

H. New development of the resources of the sea bottom and offshore areas of this region must be accomplished by methods which insure that there are no significant adverse effects to ecosystems including those involving human subsistence; if such methods are not now known, available, and economically feasible, then the proposed resource development must be delayed until methods are developed, tested, available, and economically feasible to insure acceptable effects.

The policy of the State to assess all transportation systems to and within this region in terms of total energy investment. Such assessments shall identify and separate energy requirements for both facility construction and operation. Energy requirements will be a prime decision factor in the development of a total transportation system for the region. Sage investment of energy is the prevailing policy.

Conclusion

The large number of essentially uncoordinated land use policies pertaining to the Arctic clearly indicates that future development in northern Alaska must be predicated on a joint Federal, State, and local government policy. Eventually, a joint international Arctic development policy should be formulated between the United States, Canada, and local governments to accommodate all environmental, technical, and economic concerns including: oil spill clean-up technology, marketability, transportation, fish and wildlife concerns, gravel requirements, and future land-use implications.

Prior to any Beaufort Sea OCS development, the industry should provide documentation which substantiates their ability to prevent and/or clean up oil spills in, on, and under sea ice.

Further development of northern Alaska's oil and gas potential should be contingent upon results of DOI exploration program in NPRA and upon the current industry evaluation of the Kuparuk River sands at Prudhoe Bay and at Point Thompson and Flaxman Island to the east.

NATIONAL PETROLEUM RESERVE ALASKA
DEVELOPMENT SCENARIOS
Prepared by FEA

TABLE 1

Field Size	Peak Production (BBLS/Day)	#Wells	Capital Cost (Billion Dollars)	Peak Manpower at 4th Year after Discovery	State Employment Impacts in Peak Year	NNEB Millions Dollars Per Barrel Price	NNEB	Net Fiscal Impact to State Assumed $13 Oil and Fixed 1/6 Royalty Private Development	Net Fiscal Loss to State Assuming Complete Government Development Scenario and if State is Uncompensated	Population Impacts State	Local Government Cost Increases	Peak Incremental, Development Related Additions in Population ANCH	FBKS	NS	Present Discounted Value of Local Population Increases at $900 Cost to Support Each Additional Resident
500 MMBO	100,000	64	1.7	1,500	3,700 in 5th year 520 long-term	10 13 16	$ (353) $ 276 $ 940	NONE	$41 Million	9,000 gain in 5th year 1,400 long-term	$30 Million	4,700	1,400	500	$30 Million
1 BBO	200,000	128	2.5	2,400	5,700 in 5th year 1,100 long-term	10 13 16	$ 669 $ 1,955 $ 3,302	$151 Million	$68 Million	15,000 gain in 4th year 3,000 long-term					$50 Million
3 BBO	600,000	378	5.3	5,000	12,700 in 6th year 2,800 long-term	10 13 16	$ 4,855 $ 8,855 $12,919	$473 Million	$159	33,000 gain in 6th year 7,000-8,000 long-term	$120 Million	16,000	5,000	2,400	$120 Million

Table 2 - Development Scenarios by the State of Alaska

Scenario	Lease Date	Field Size	Depth Feet	Discovery Date	Ownership	Proximity to Producing Field	Shared Facilities	Production Start Date	Production Peak Amount MMB/Year	Production Peak Dates	Secondary Recovery Type	Secondary Recovery Start Date	Peak Workforce Number	Peak Workforce Date	Roads Miles	Pipelines Length Miles	Pipelines Size Diameter	Water Personal	Water Millions of Gallons Drilling	Water Millions of Gallons Secondary Recovery	Water Millions of Gallons Total	Gravel Million Cubic Yards Basic Roads	Gravel Million Cubic Yards Airstrips	Gravel Million Cubic Yards Total
NPRA-1	1981 1985	0	0	0	S&F Offshore	None	None	n/a	0	n/a	None	n/a	600	1985	0	0	0	24.9	79.0	0	103.9	0	0	0
NPRA-2	1981	600MMB	7,000	1983	S Offshore Smith Bay	None	None	1992	43.8	1995-2001	Water Injection	1997	850	1991	161	160	14"	129.3	48.2	525.6	703.1	2.248	3.760	.160	6.168
NPRA-3	1985	300MMB	10,000	1987	S Offshore	None	None	1995	24.0	1998-2003	Water Injection	2002$	375	1997	85	85	10"	66.2	47.4	0$	113.6	1.297	1.998	.160	3.455
NPRA-4	n/a	0	0	0	F	None	None	n/a	0	n/a	None	n/a	300	1978-1986	0	0	0	28.7	70.7	0	99.4	0	0	0	0
NPRA-5	n/a	1000MMB	5,300	1978	F	None	None	1987	73.0	1990-1996	Gas Injection	1994	900	1992	195	195	18"	188.8	61.2	0	250.0	3.266	4.577	.160	8.003
NPRA-6	n/a	600MMB	8,600	1984	F	None	None	1992	43.8	1995-2001	Water Injection	1999	1250	1986	125	125	14"	141.4	79.5	262.8	483.7	2.248	2.938	.160	5.346
NPRA-7	n/a	300MMB	4,000	1986	F	105 miles to WAA-2 Pipeline and Road	WAA-2 Pipeline and Road	1993	24.0	1996-2001	Gas Injection	1999	425	1995	15	15	10"	86.7	76.1	0	162.8	1.297	.353	.160	1.810
WAA-1	n/a	0	0	0	Arctic Slope Regional Corp	None	None	n/a	0	n/a	None	n/a	125	1978-1983	0	0	0	11.8	32.6	0	44.4	0	0	0	0
WAA-2	1977	600MMB 300MMB	6,000 5,000	1979 1981	A.S.R.C. A.S.R.C.	120 mi. from 300MMB to 600MMB	Pipeline and Road	1987 1987	43.8 24.0	1990-1996 1990-1995	Water Injection	1994	1475	1986	415 85	415 85	18" 10"	231.0	46.8	1,256.7	1,534.5	2.248 1.297	9.753 1.998	.160 .160	12.161 3.455
PBSA-1	1979	0	0	0	S&F	None	None	n/a	0	n/a	None	n/a	275	1979-1983	0	0	0	13.8	38.5	0	52.3	0	0	0	0
PBSA-2	1979	600MMB	10,000	1981	S Offshore	Prudhoe Bay	Airstrip	1985	43.8	1988-1994	Water Injection	1991	750	1985	30	30	14"	156.0	51.8	988.5	196.3	2.248	.705	0	2.953
PBSA-3	1982	600MMB	10,000	1984	S Offshore	Prudhoe Bay	Airstrip	1988	43.8	1991-1997	Water Injection	1994	750	1986	30	30	14"	145.9	49.9	961.5	1157.3	2.248	.705	0	2.953
PBSA-4	1989	600MMB	10,000	1991	S Offshore	Prudhoe Bay	Airstrip	1995	43.8	1998-2004	Water Injection	2002$	750	1995	30	30	14"	93.7	46.1	0$	139.8	2.248	.705	0	2.953
PBSA-5	1992	600MMB	10,000	1994	S Offshore	Prudhoe Bay	Airstrip	1998	43.8	2001-2007	Water Injection	2005$	750	1998	30	30	14"	67.9	44.0	0$	111.9	2.248	.705	0	2.953
PBSA-6	1985	0	0	0	S	None	None	n/a	0	n/a	None	n/a	275	1985-1989	0	0	0	14.5	45.0	0	55.0	0	0	0	0
PBSA-7	1985	300MMB 6,000 10,000	6,000 10,000	1987 1988	S S	None	None	1990 1991	24.0 24.0	1993-1998 1994-1999	Gas Injection	1997 1998.	825	1992	40 30	40 30	10" 10"	134.9	8.8	0	143.7	1.297 1.297	.940 .353	.160 .160	2.397 1.810
CNSA-1	1977	0	0	0	A.S.R.C.	None	None	n/a	0	n/a	None	n/a	125	1978-1982	0	0	0	11.0	30.5	0	41.5	0	0	0	0
CNSA-2	1977	600MMB 300MMB	13,500 7,900	1978 1980	A.S.R.C. A.S.R.C.	50 mi. from 600MMB to 300MMB	Airstrip Pipeline Road	1982 1983	43.8 24.0	1985-1991 1986-1991	Gas Injection	1989 1990	1000	1983-1989	120 120	120 120	18" 18"	265.3	46.9	0	312.2	2.248 1.297	2.820	.160	6.525
ANWR-1	1987	0	0	0	S&F Offshore	None	None	n/a	0	n/a	None	n/a	225	1988-1991	0	0	0	10.3	28.5	0	38.8	0	0	0	0
ANWR-2	1987	600MMB	6,000	1989	S Offshore	None	None	1993	43.8	1996-2004	Water Injection	1999	650	1994	55	55	14"	106.8	37.3	262.8	406.9	2.248	1.293	.160	3.701
ANWR-3	1992	5000MMB	10,000	1993	F	None	None	1999	365	2000-2007	Water Injection	2006$	3900	1998	90	90	42"	293.8	16.7	0$	310.5	11.696	2.160	.160	15.416

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The Joint Federal–State Land Use Planning Commission for Alaska was created by Congress and the Alaska Legislature to provide a statewide land use planning process that will insure the economic development of the State in a manner that is compatible with the social and economic well-being of the public, their interests, and the environment.

The Commission also is to improve coordination and resolve conflicts between the State, Federal government, and private landowners in the State, and recommend laws, policies and programs to the President, Congress and the Governor of Alaska for a coordinated comprehensive statewide land use planning process.

The Commission, created by the Alaska Native Claims Settlement Act of 1971, is headed by the Governor of Alaska or his full-time Co-Chairman, and by a Federal Co-Chairman appointed by the President of the United States. Four Commissioners are appointed by the Secretary of the Interior, and four by the Governor of Alaska.